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CROPS

THROUGH ORCHARD FERTILIZATION

SEE INSIDE COVER

WHY ORCHARD FERTILIZATION?

WHETHER in pear growth (above) or peach production (front cover), the answer is the same: Orchard fertilization is important in attaining and *maintaining* adequate nutrition for profitable fruit and nut production. This issue presents the thinking of some official agricultural scientists on this subject.

In above picture, potash deficiency on pear growth is evident. Normal spur leaves at top left have .7% K or higher in midsummer. K deficient leaves at top right had less than .4% K. Fruits at left are from potash treated trees. Small fruit at right is from K deficient trees. (Agnew, California.)

On front cover, potash deficient peach tree (left) displays yellowish green leaves, curled upward at edges along entire leaf, showing some scorch along edges when rolling severe. Small peaches below from K deficient trees, large peaches from adjacent tree receiving adequate potash. Potash hunger becomes obvious when matured leaves taken from near base of current year's growth in midsummer analyze less than 1.0% according to Lilleland and McCollam of California.

FERTILIZING WESTERN ORCHARDS

By Omund Lilleland and M. E. McCollam*
California

FRUIT trees require a fertilizer treatment which is generally distinct and often in contrast to annual crops.

Fruit trees frequently contrast sharply with field crops in their deeper rooting nature, their perennial growing habit, their ability to store nutrients from one year to the next, and their greater need for certain specific elements.

Fruit trees require all the so-called major elements including nitrogen, potassium, phosphorus, magnesium, calcium, and sulphur, and the so-called minor elements, including manganese, iron, boron, zinc, and copper. Excepting perhaps calcium and sulphur, all these elements have been found deficient in commercial orchards at one time or another.

Profitable orchard fertilization frequently depends on recognizing various deficiencies as expressed by (1) leaf and growth patterns, (2) fruit symptoms, and (3) chemical composition and analysis of the leaves.

Comparative leaf sampling in good and poor areas within an orchard often reveals nutritional disorders more clearly than reliance on a single sample. Due to interrelationships of nutrient elements in the leaf, an analysis *for more than one element* is often very helpful. In some cases, bark wood and fruit analyses are also helpful. Although soil analyses may help in some instances, they are difficult to interpret in the case of deep rooting fruit trees.

A diagnosis can generally be confirmed by leaving some trees unfertilized. This is always advisable in seeking to solve fertility problems.

Nitrogen

Nitrogen is the element most often deficient in orchard soils.

Lack of it is reflected in (1) pale green and smaller leaves, (2) lack of terminal shoot growth, (3) small highly colored and early maturing fruits, and (4) early fall coloring and loss of foliage.

Frequently the current season's bark growth in the pear and peach exhibits a reddish fall tinge when low in nitrogen.

Analysis of mature leaves in midsummer should generally contain a minimum nitrogen content of 2.0 per cent on a dry matter basis.

Although 100 lbs. of actual nitrogen per acre generally has proved adequate for most western orchards, field trials are the best way to determine how much N is needed to correct and maintain adequate nutrient level. Certain fruit species such as peaches may require more than 100 lbs. N per acre while apricots may need less.

Excessive N may cause poorly colored fruits, retarded ripening, and unsatisfactory fruit quality. Light textured sandy soils, especially when frequently irrigated, may need more nitrogen and/or split applications than heavier soil types. Somewhat larger

* *Pomologist, University of California, Davis and Consulting Agronomist, American Potash and Chemical Corporation.*

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Dr. Omund Lilleland, University of California Pomologist since 1922, moved from Norway to California at 6 to join his sea captain father on the West Coast in 1905. He remained to help pioneer in leaf analysis research, to help develop massive potash applications on K-deficient orchard soils, to lecture on pomology, and to author over 50 papers in the field.

amounts of nitrogen can be applied in hot interior climates than in cool coastal areas.

Nitrogen Fertilizers

Several forms of nitrogen fertilizers are available to the grower, showing little difference in response (in orchard tests) when the same amount of nitrogen is applied in each case. Therefore, the cheapest per unit of nitrogen has been most often recommended.

In some orchards, certain conditions might modify the above recommendation. For example, (1) the various forms of carriers of N can affect soil acidity and water penetration, (2) some leach more readily than others, (3) some are less readily available, (4) some may carry an element already present in excess, and (5) some may react unfavorably on the soil physical condition.

Such effects may warrant the choice of a particular nitrogen fertilizer under certain conditions. Ease and cost of application is also a factor in choosing a nitrogen fertilizer.

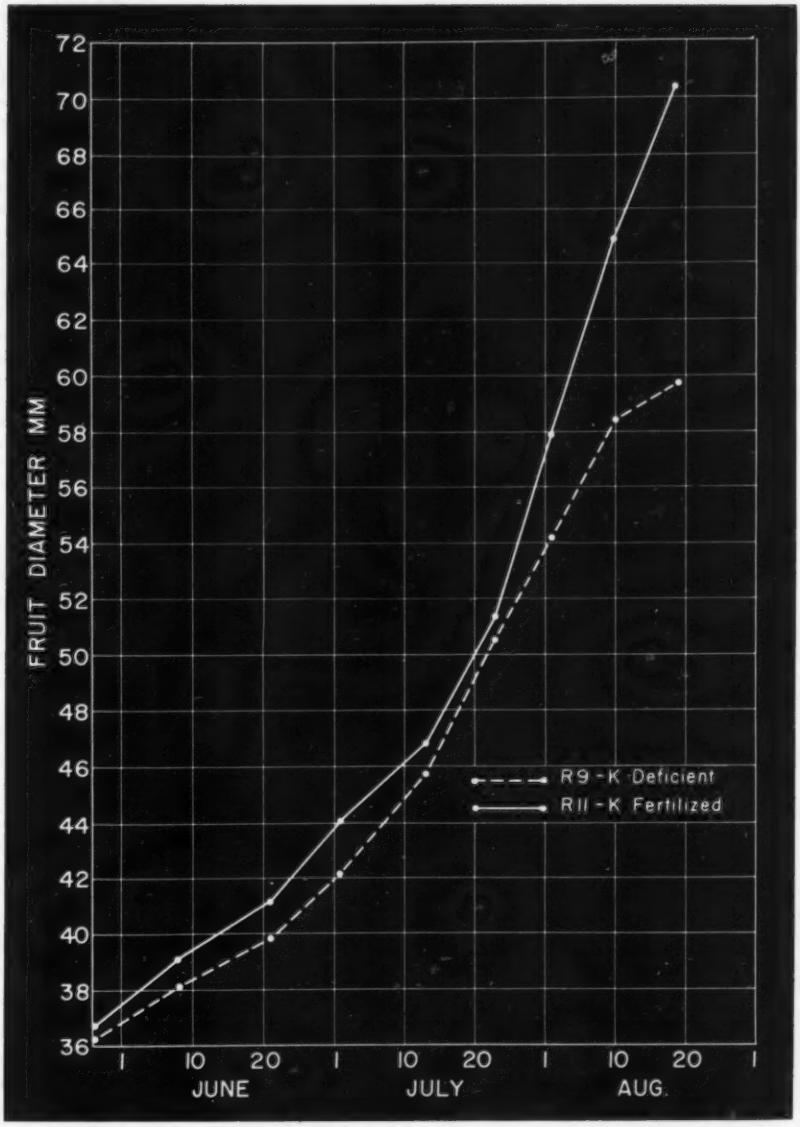
The recent trend toward applying some nitrogen as a foliar spray has not been widely accepted, because stone fruits generally fail to absorb nitrogen from urea sprays. However, such a program may result in better fruit color in some apple orchards where carefully controlled supplemental N spray programs have been used.

But—the main application of nitrogen is and must be to the soil.

Application Time

The time of application—fall, winter, or spring—depends on several factors. Where there is a continuous program of nitrogen fertilization, application time is not too critical. There is often some carry-over from the previous season.

Under semi-arid conditions, application time should, if possible, be related to rainfall. Failure of spring rains may reduce effectiveness of spring applications. Since little or no nitrogen is lost from the tree root zone under winter rains, the fall on dry ground is a convenient time to apply



The striking difference in seasonal growth of potash deficient and potash treated Halford peach fruits at Delhi, California, is shown here. Note maximum size difference at harvest.

fertilizers in most cases. If he does it just before leaf fall, a smart grower can base the amount on individual tree needs as indicated by leaf color and defoliation.

Other factors—such as winter irrigation, plowing under of heavy cover crops in the spring, very light and frequently irrigated soils, and the type of nitrogen fertilizer selected—will also

enter into application timing.

Phosphorus

Fruit trees, unlike crop plants, are seldom deficient in phosphorus, appearing to get enough from the soil even when soil tests show very little available phosphorus. Field tests have often shown fruit trees growing very well in soils where annual plants fail without phosphorus fertilizers. An orchard cover crop may frequently respond to phosphorus without any tree response. To increase cover crop growth, phosphorus should be considered. But it is rarely needed as an applied nutrient for western orchard trees.

A purplish bronze leaf color has sometimes been associated with phosphorus deficiency. Phosphorus content as low as 0.10 per cent, dry matter basis, in mature leaves in midsummer may produce satisfactory tree growth, abundant data show.

Since phosphorus fertilizers are rapidly fixed and immobilized in the surface soil, large amounts and deep placement have generally been used to get this element down into the tree root zone for experimental tests. Later leaf analysis tests for tree root absorption have frequently shown negative response with phosphorus.

Potassium

In contrast to phosphorus, orchard trees need potassium (K). This has been demonstrated with practically all fruit tree species. Though potassium deficiency is not as widespread as nitrogen hunger, recent investigations have shown greater frequency than ever before realized.

Potassium deficiency symptoms can now be described rather accurately, and a leaf analysis method to confirm the visual symptoms has been established. Such combined diagnosis generally eliminates some misinterpretations that can occur when leaf analysis or tree symptoms are considered separately. Growers unfamiliar with leaf symptoms can get some potassium appraisal of their soil by careful leaf sampling and analysis. County agents can generally describe the methods used to select leaves for analysis as well as supply addresses of commercial laboratories for testing them.

M. E. McCollam, consulting agronomist, American Potash and Chemical Corporation, is well known to the field of fruit tree nutrition. He was a long-time chairman of the Soil Improvement Committee of the California Fertilizer Association, a member of the Soil Science Society of America, the American Society of Horticultural Science, Western Society of Soil Science, and the National Joint Committee on Fertilizer Application. The city of San Jose, California, has named one of its schools in his honor.

A guide to leaf symptoms of potash deficiency and a leaf sampling schedule for seven major fruit and nut crops —apple, apricot, almond, prune, plum, peach, and pear—is presented on page 5, facing this column.

On deciduous fruit trees, potassium deficiency frequently becomes more evident with the approach of bearing and heavy fruiting. Leaf symptoms have been noted on young vigorously growing almond trees previous to fruiting, however. A decline in available potassium in the subsoil combined with deeper rooting of older trees may also explain later appearance of tree symptoms. Areas of acute potassium symptoms are often created when grading and leveling operations remove surface soil.

Continued on page 46

A GUIDE: TO POTASH HUNGER SYMPTOMS AND LEAF SAMPLING SCHEDULE

Crop	Symptoms of K Hunger	Place to Take Sample	When to Sample	Hunger Evident
Apple	Leaf scorch first on basal shoot or spur leaves, progressing toward younger leaves as season advances. With continued deficiency, leaves become small, trees remain stunted, fruits fail in size.	Matured leaves on spurs, or leaves near base of current year's growth.	June 15 to July 15	When sample leaves analyze less than 1.0% K.
Apricot	Leaves tend to roll upward, lacking dark green color. Foliage tends to be sparse, shoot growth reduced. Marginal scorch frequently results. Die-back in severe cases. Yields and fruit size reduced. Threshold value higher since apricot leaf contains more K than other stone fruits.	Matured leaves on spurs, or leaves near base of current year's growth.	June 1 to July 15	When leaves, analyzed by standard procedure, show less than 2.0% K.
Almond	Tip burning of leaf early in season. Often marginal scorch near tip of leaf, causing boat shaped appearance, especially on leaves of vigorously growing shoots. Leaf color generally pale, resembling N shortage. Second growth cycle may occur from lateral buds of current growth. Continued K hunger causes small leaves, sparse foliage, poor growth, die-back of terminals, reduced bearing.	Matured leaves on spurs, or leaves near base of current year's growth.	June 1 to July 15	When sample leaves analyze less than 0.7% K. (Injury from sodium chloride also produces leaf scorch and low K content, but can be detected by high sodium or chloride analysis.)
Prune and Plum	Leaf scorch on both Japanese (P. Salicina) and European (P. Domestica) types. Excessive bearing (especially in prunes) intensifies severity of leaf scorch and resultant die-back. Fruits small and poor in color. For complete correction, control of cropping must sometimes be considered in addition to potassium applications.	Matured leaves on spurs, or leaves near base of current year's growth.	June 15 to July 15	When sample leaves analyze less than 1.0% K —realizing symptoms and leaf analysis can fluctuate markedly with alternate of light & heavy crops.
Peach	Generally not evident until late summer, intensified by heavy bearing. Longitudinal upward rolling of leaf most evident on terminal growth. First few basal leaves on a shoot frequently normal. Rolling more definite & distinct with proximity to terminals. Leaves pale green, showing some scorch along edges when rolling severe. Fruits small, poorly colored, ripen earlier than on normal trees.	Matured leaves near base of current year's growth.	June 15 to July 30	When sample leaves analyze less than 1.0% K.
Pear	Leaf rolling combined with silver brown discoloration of exposed underside of leaf. Leaves smaller, pale green. Tree sparse, shoot growth weak. Distinctly smaller fruits mature earlier. Leaf symptoms may not be distinct until harvest time.	Matured leaves on spurs, or leaves near base of current year's growth.	June 15 to July 15	When sample leaves analyze less than 0.7% K.

NAME_____

ADDRESS_____

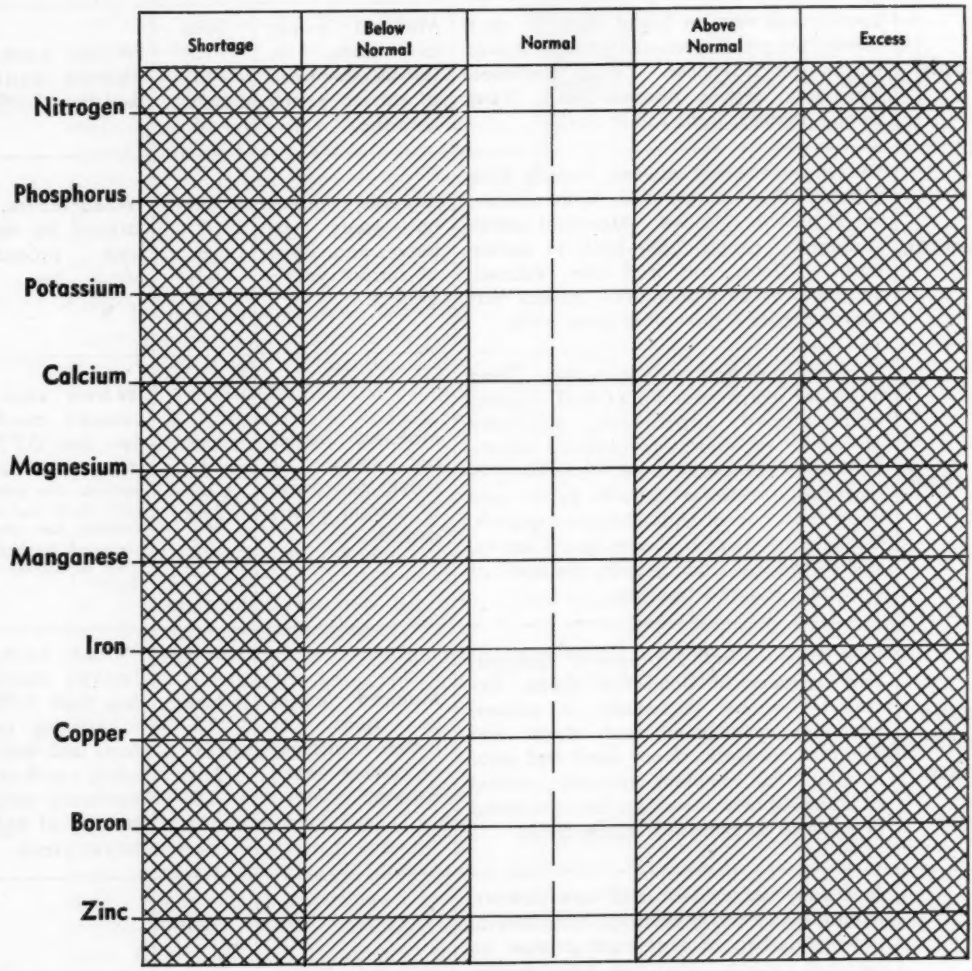
SAMPLING DATE_____

NUTRIENT-ELEMENT BALANCE CHART

VARIETY_____

AGE OF TREES_____

LOCATION_____



Nutrient-element	% in Leaves	Chart Index
Nitrogen		
Phosphorus		
Potassium		
Calcium		
Magnesium		

Nutrient-element	% in Leaves	Chart Index
Manganese		
Iron		
Copper		
Boron		
Zinc		

Department of Horticulture, Michigan State University

APPLYING FERTILIZERS TO ORCHARDS

To do it successfully requires some knowledge of the tree's physique or physiology

By A. L. Kenworthy

Michigan State University

Of how fruit and nut trees differ from row crops . . . in root system and activity . . . in size and storage reserves . . . in certain tolerances and application demands.

FRUIT and nut trees are different from row crops. The primary difference is that trees are perennials and most row crops are annuals usually started from seed each year.

There are many other differences. For example, they belong to different plant families. Deciduous fruits (apple, peach, pear and cherry) belong to the rose family. Citrus belongs to the Rue family (a group of herb-like shrubs and trees). On the other hand, corn, wheat, and cereal crops belong to the grass family and the vegetable crops are members of many plant families of which many weeds are also members—the cabbage family, for example.

Surely, we would not treat lawns, weeds, vegetables, roses, and oranges alike.

Why the Difference

Fertilizer needs of perennials and annuals differ in many ways. Some of the major physiological factors behind these differences are:

1. Extensiveness of root systems.
2. Size of above ground parts.
3. Storage reserves within the plant.
4. Almost continuous root activity.
5. Lack of cross-transfer of nutrients from one side of the plant to the other.

Tree fruits and nuts have certain characteristics that most annual row crops do not have. In addition, tree fruits and nuts seem to tolerate acid soils and, perhaps, a wider range of soil pH more effectively than row crops. At the same time, tree fruits seem more susceptible to shortages of minor elements than row crops.

Once established, a tree remains in one location from one to several decades. The reserve soil supply of a nutrient may be exhausted during this time. Also, the extensive root system more fully exploits the soil mass than the root system of an annual seed crop would do. Thus, the fruit and nut grower must be aware of the nutrient supplies available in both his subsoils and surface soils.

Full-Time Absorption

Being a perennial gives a tree certain advantages. The roots are usually actively absorbing nutrients even

Dr. Alvin L. Kenworthy is professor of horticulture at Michigan State University. He has studied, taught, and done research at Oklahoma State, Kansas State, Washington State, Delaware, and Florida Agricultural Experiment Station, in addition to MSU. Author of a score of professional articles, he has toured 44 experiment stations east of the Rockies. His work on leaf analysis has introduced it to many fruit growers as a major tool.

when the tree is dormant. These nutrients are stored within the root and transfered to above ground parts when the next flush of growth demands them. Also, large quantities of carbohydrates are stored in the limbs, branches, and roots and may be used for initiating new root and shoot growth. (In contrast, the seed crop must absorb all nutrients and manufacture all carbohydrates, except for a small reserve supply in the seed during the period of active growth.)

This characteristic permits the tree to perform well on soils that seem to have an inadequate nutrient supply. Probably, the most outstanding example of this is with phosphorus. Why do trees seldom show a response to phosphorus applications?

Time of Application

The ability of roots to absorb and store nutrients while the tree is dormant or between flushes of growth influences application time. The fertilizer nitrogen, for example, may be applied during the dormant period and become quickly available when growth is renewed in the spring. Certain nutrients, such as nitrogen, are synthesized into organic forms immediately upon absorption and do not accumulate in ionic form, such as nitrates.

Also, perhaps by coincidence, the highest nitrogen requirement occurs in the spring when there is a sudden flush of growth. To protect against winter injury, the nitrogen level should decrease during the season to a near deficient level in the fall. Maximum fruit quality (sugars, acids, color, etc.) is usually found when the nitrogen level is lower near harvest than at blossom time.

All Sides Necessary?

Since nutrients do not cross-transfer from one side of a tree to another, the most general practice is to apply fertilizer on all sides of the tree. A given section or limb of a tree is fed directly from a corresponding section or branch of the root system. But, this section or branch of the root system does not grow in the same manner and direction as the above-ground part.

The roots may originate on the same side of the tree as the limb it feeds but later extension and branching may develop in any direction. Consequently, much interlacing of roots from different sections or branches of the root system occurs. In fact a root originating on one side of the tree may eventually branch and grow on all sides of the tree.

Thus, a supply of nutrients on one or more sides of the tree may be absorbed by roots originating from sides of the tree not receiving nutrients.

Only A Few Roots Needed

Only a relatively few roots are necessary to absorb all the nutrients needed by the tree. In fact, a generally low level of soil fertility usually promotes greater root extension and branching. If soil fertility is unusually high, root growth will be restricted and root extension is mainly a result of moisture conditions.

Limbs And Trunks Useful

Nutrient shortage in a tree may be corrected by many methods. While the long life of a tree may make it susceptible to nutrient shortages, the size of trunk and above ground parts make

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certain corrective measures possible. In addition to soil applications, these corrective measures may include:

1 Early season foliar sprays.

2 After harvest foliar sprays.

3 Dormant sprays to twigs and branches.

4 Injections into the trunk or branches of the tree.

Such corrective methods have helped correct minor element shortages and are often used in preference to soil applications. In fact, foliar sprays and/or injections, can supply sufficient quantities of any nutrient to eliminate or prevent a deficiency.

These characteristics of a tree must be considered when diagnosing nutrient needs of fruit and nut crops. They influence the relative merits of soil testing, tissue testing, foliar analysis, deficiency symptoms, and field trials as diagnostic tools.

Basically, four factors determine successful fertilizer usage in orchards: the (1) *right kind* at the (2) *right time* in the (3) *right place* in the (4) *right amounts.*

Available diagnostic methods may tell us the *kind.* Research and experience will tell us the *time, place,* and *amount.*

THE END

Highly productive citrus groves put a heavy drain on natural soil fertility and fertilizer programs

CITRUS NEEDS ADEQUATE NUTRITION

By Herman J. Reitz **University of Florida**

THE nutritional requirements of citrus trees basically are no more exacting than those of many other crops.

Although citrus trees yield well on a fairly wide range of nutritional levels above distinct deficiency, most growers find high nutritional levels most profitable.

A highly productive citrus grove places a very appreciable drain on natural soil fertility and fertilizer programs. Crop removal alone for 500 boxes of oranges (90 lb. each) per acre requires 145 lb. potassium (as K_2O), 80 lb. nitrogen (N), 35 lb. calcium (as CaO), 17 lb. magnesium (as MgO), and 23 lb. phosphorus (as

P_2O_5). Since fertilizer cost is only part of the usually high citrus production costs, growers cannot afford to jeopardize their entire program through inadequate nutrition.

Since citrus has been planted primarily where warm sites were available with good access to markets, various soil fertility conditions have been encountered. Soils used for citrus range from very fertile soils in Texas to some very infertile soils in Florida. Citrus trees are quite adaptable to soils of different textures as long as good drainage is provided, and research has been able to cope with many problems of soil infertility.

Recognizing Deficiency Symptoms

Nitrogen is the most commonly observed nutritional deficiency of citrus, as with most other fruit trees. It is applied almost universally in all commercially important producing areas, sometimes with little proof of actual need for supplemental nitrogen. When the need does exist, optimum N rates are applied. A more critical evaluation of nitrogen requirements of citrus trees is being made at present in a number of areas.

Zinc deficiency has been observed in nearly as many areas as has nitrogen deficiency. Although citrus roots can absorb as much as 4,000 ppm of zinc from nutrient solutions, even under these conditions much smaller amounts of zinc (less than 400 ppm) appear in the leaves. In soils, zinc is frequently held in unavailable forms, particularly at high pH levels. Radioisotope studies have further shown that zinc once absorbed into leaves may not be translocated downward into stems, being entirely lost when the leaf falls. Thus, zinc nutrition of citrus trees seems very complex.

Iron and manganese deficiencies have been very commonly reported on soils high in lime. Magnesium and boron deficiencies have sometimes been reported and, less commonly, deficiencies of copper, potassium, molybdenum, and phosphorus. Phosphorus would probably have been found deficient more frequently if it had not been used so widely in some areas without clear evidence of its need.

A very rarely observed deficiency is that of calcium. It is believed to have been developed in the field only under experimental conditions in Florida.

Economic Losses From Unfavorable Nutritional Levels

Very serious results are associated with nutritional deficiencies: (1) reductions in growth, (2) various characteristic leaf chlorosis patterns, (3) premature defoliation usually accompanied by increased sensitivity to cold winter weather, (4) premature dropping of fruits sometimes accompanied by fruit splitting, (5) die-back of twigs and branches, (6) pronounced alternate bearing, and (7) reduction in yield and fruit quality.

To prevent reduction in growth, leaf chlorosis, premature defoliation usually accompanied by increased sensitivity to cold winter weather, premature dropping of fruits sometimes accompanied by fruit splitting, die-back of twigs and branches, pronounced alternate bearing, and reduction in yield and fruit quality

The need for correcting nutritional deficiencies is obvious. Less obvious but very important is the need to attain and maintain certain actual nutritional levels.

Dr. Herman J. Reitz is Horticulturist in Charge of Citrus Experiment Station of the University of Florida. A native of Kansas, he earned his B. S. from Kansas State, his M. S. and Ph.D. from Ohio State University.

For example, potassium has a series of different effects over a wide range of nutritional levels. In Central Florida, a low level of potassium below about 0.7 per cent K in leaves results in excellent orange fruit color and early maturity, but also results in low yields, heavy drop of fruit, and small fruit sizes. The small fruit size is a very important factor to fresh fruit shippers, especially of the generally under-sized early orange varieties.

At the other extreme, supplies of potassium greater than needed to produce maximum fruit yield (above about 1.7 per cent K in leaves) increases the proportion of coarse, green fruit, an undesirable characteristic. Particularly in grapefruit, high potassium nutrition is accompanied by high levels of acidity in the fruit juice, thus delaying maturity as much as one to two months, decreasing palatability of the fresh fruit, and making the fruit less suitable for processing into high-quality canned products.

Intermediate potassium level (1.0 to 1.5 per cent K in leaves) avoids many of these difficulties. Further, intermediate K levels result in higher yields of soluble solids per acre for the frozen concentrate producer than either extremely low or high levels. Thus, not only the observable deficiencies, but also the actual nutritional levels above these are very important to citrus growers. A grower may need to alter his potassium program to suit his market requirements.

Why Nutritional Disorders

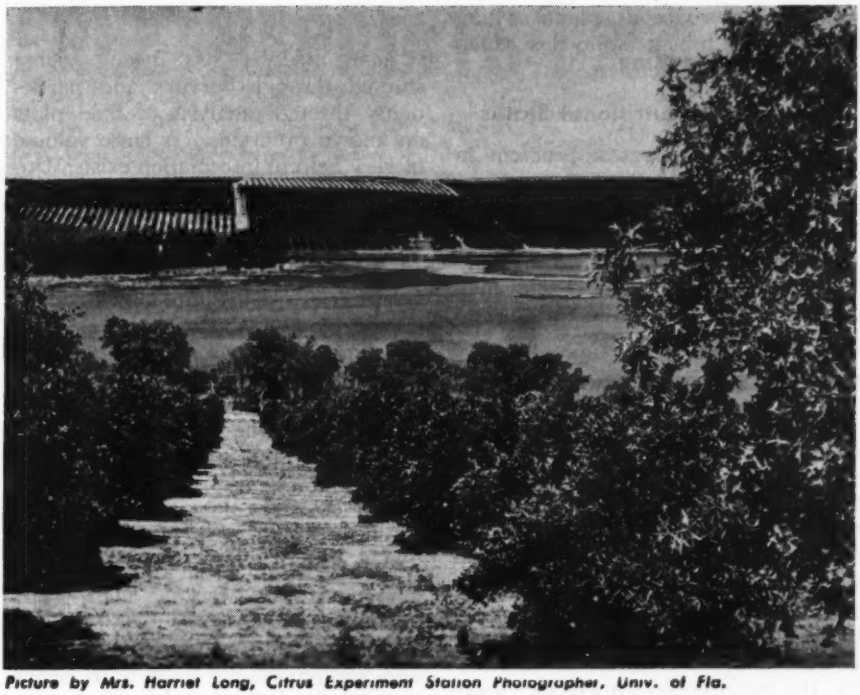
Non-optimum nutritional levels in citrus trees are usually caused by (1) actual deficiencies of the elements in soils, (2) unavailability of elements through soil fixation complicated by various pH effects, and (3) interactions or antagonisms of one element acting in the presence of another. In poorly buffered soils, examples of all these effects can be readily found, sometimes in the same grove over a period of years.

Many of the sandy soils of Central Florida's hill section had less than five pounds of total copper per acre six inches in their natural condition, causing copper deficiency to be very commonly observed at one time. The beneficial effect of copper applications was widely known by 1935, with routine copper applications becoming a standard practice.

After years of being used in mixed fertilizers and fungicidal sprays, copper accumulated in the organic matter of some surface soils up to 600 pounds (as Cu) per acre six inches. For groves on such soils, copper deficiency had long since become unknown when iron chlorosis became a pressing (*at first apparently unrelated*) problem.

Iron deficiency had been previously observed only on soils high in lime and on very light colored sands where total iron was low. Where these two conditions did *not* exist and iron chlorosis still showed up, research found that high soil copper was reducing iron availability by *ion antagonism*. Experiments further indicated that liming would reduce the availability of copper proportionately more than it would reduce the availability of iron. Therefore, liming had a net beneficial effect of reducing iron chlorosis symptoms, an opposite result of what would have been found under low copper conditions.

The iron problem was also corrected under acid soil-heavy metal toxicity



Picture by Mrs. Harriet Long, Citrus Experiment Station Photographer, Univ. of Fla.

Such citrus groves require the best management—including a carefully planned nutrient program

conditions by developing effective chelating agents, particularly ethylene diamine tetraacetic acid. This chelating agent is fairly stable in the soil and extremely effective in holding iron in soluble form, available to citrus trees.

Supplying Plant Nutrients

Methods for attaining optimum nutritional levels in citrus trees depend on the problem involved. Ordinary soil applications of soluble fertilizer salts are quite effective in many cases. Under favorable conditions, the results of nitrogen applied to the soil can be seen in a few days. Potassium is absorbed very readily by citrus trees under acid soil conditions, but rather slowly in calcareous soils. Under the latter condition, leaf potassium level is much lower than on acid sands, but still can be adequately supplied from soluble fertilizer materials.

Sprays containing the nutritional elements are applied to the leaves in some cases, most commonly on calcareous soils. Zinc and manganese deficiencies have been corrected by this method where availability of the element in the soil was inadequate. Magnesium deficiency has also been corrected by foliage sprays under similar circumstances.

Although such sprays do give an immediate practical answer for acute problems, over-all they are highly inefficient. Much greater quantities of the element than the plant requires must be applied to the leaf surfaces if sufficient absorption is to be induced through the heavy cuticle of citrus leaves. This contrasts quite sharply

with some herbaceous plants where uptake from foliage sprays is much more rapid and extensive.

Determining Nutritional Status

Currently the greatest problem in citrus nutrition is determining current and future nutritional status of the tree. Useful criteria for making such judgments are (1) symptom observation, (2) leaf analysis, (3) soil analysis, and (4) (perhaps in the future) fruit analysis.

Symptom Observation

In the hands of an experienced and well-informed citrus grower, symptom still remains the simplest and most reliable method for determining the tree's nutritional status. It is unlikely to be replaced entirely by any analytical system. With an accurate record of a grove's fertilization history and a background of observing experiments and demonstrations in his locality, the experienced grower can make a fairly satisfactory over-all analysis of the tree's nutritional status.

His observation for visible deficiency symptoms of nitrogen, magnesium, zinc, copper, boron, manganese, molybdenum, and iron will give him as good a picture of the grove's deficiency problems as can be obtained through much analytical data on leaves, fruit, and soil. Observing fruit characteristics can also provide some information on nutritional status, particularly for nitrogen and potassium.

Unfortunately, this method informs the grower of only a part of the problem. That is, visual observation usually would not detect unnecessarily high (and hence expensive) use of some fertilizer elements. Citrus trees, for example, may be adequately supplied with magnesium if the foliage analyzes 0.30 to 0.35 per cent in four- to six-month-old leaves. Some groves being fertilized with magnesium are known to have magnesium levels as much as twice this high, indicating an uneconomic use of magnesium.

Leaf Analysis

Leaf analysis has been widely studied through surveys and particularly through analysis of field plots on known programs. A large volume of very helpful information exists. Uneconomically high usage of elements may be detected by leaf analysis studies. The nutritional status for elements not showing distinctive visible symptoms, as potassium, may be determined by leaf analysis. Also, over a period of years, regular annual leaf sampling and analysis could show a grower the direction his nutrition program was leading, enabling him to apply preventive measures before the grove entered any undesirable range of leaf analysis values.

There appears to be an unfortunate tendency to interpret too closely leaf analysis results and not allow sufficiently for year-to-year variations presumably related to weather conditions and sampling and analytical errors. Nevertheless, this highly valuable research tool seems to offer much promise for commercial exploitation in the coming decade.

Although research still remains to be done in this area, ranges for satisfactory tree performance are becoming established. For four- to five-month-old spring flush leaves on non-bearing shoots, satisfactory leaf analysis values in Florida may be as follows: *nitrogen*, 2.5-3.0 per cent; *phosphorus*, more than 0.10 per cent; *potassium*, 1.0-1.5 per cent; *magnesium*, more than 0.35 per cent; *manganese*, *zinc*, and *boron*, more than 30 parts per million.

Soil Analysis

Soil analysis will doubtless be used to a greater extent in future than at present, particularly for phosphorus, but possibly for all elements that are retained by the soil in semi-permanent reserves.

In relatively infertile soils, soil anal-

Continued on page 31

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FREE REPRINTS

	Serial Number	Number Desired
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WHICH?

THE answer is obvious. The prune trees on the left were fertilized—in this case, with potassium. Check trees are on right in this Gaspar Orchard at Gilroy, Santa Clara County, California.

Farm Advisor Leon Tichinin of Santa Clara County advises the prune growers of his area in this way:

"Were your prune sizes small—did your leaves turn yellow, burn, fall off? If so, you probably also found that your dry-away was terrifically high and prune sizes in the 110 to 120's.

"Why? Lack of potash is the answer."

Tichinin then advises, "As soon as the last prune picker is out of the orchard, apply 25 lbs. of sulphate of potash per tree to the affected part of the orchard. Apply the potash 8 inches down and 3½ to 5 feet from the tree with drill attachments, and follow with a good irrigation."

From several cooperative experiments, California Chemical Company agronomists have found potash response to prunes in Santa Clara County.

1960 Results	Check	25 pounds sulfate of potash per tree applied fall of 1959
Lbs. prunes per acre	1400	3421
No. of prunes per pound	75	66
% sugar on Aug. 8—2 weeks before harvest	17.5	20.0
Dry-away	2.78	2.76
Crop Value/Acre	$245.00	$598.68
Fertilizer Cost	0	$55.37
Net profit for potash over check		$298.31

—Western Potash News Letter

The Region

MINERAL nutrients demanded by profitable apple tree production depend partly on soil reaction or pH.

On eastern United States acid type soils, nitrogen, potassium, magnesium, boron, perhaps phosphorus, and (only rarely) zinc must be considered. In western United States, magnesium deficiency is not usually a problem on the high pH soils found there. But iron and manganese can be a problem, while some copper deficiency has been reported on apple trees. Recent studies suggest an association between calcium nutrition and stippen or bitter pit. Experimental work is in progress.

APPLE NUTRITION CAN BE MULTIPLE CHALLENGE

Of the essential plant nutrients, sulfur, molybdenum, and perhaps chlorine are the only ones yet unmentioned. Sulfur and chlorine are used so widely in sprays and fertilizers that their deficiency probability on apple trees is remote. Although the bark on apple trees growing in acid soil and suffering from a disorder called "measles" tested low molybdenum and high manganese, applications of molybdenum did not correct the "measles."

Depending on the orchard's location, a grower can estimate the probability of certain deficiencies through the basic mineral constituents of the soil, degree of weathering, previous fertilizer history, and soil reaction or pH.

Even over an area the size of New York, soils tend to be more acid and *magnesium deficiency* a greater problem in the Hudson Valley area than in western New York (Lake Ontario Region).

Boron deficiency is more a problem in the Champlain and Hudson Valley areas than elsewhere.

While *potassium deficiency* occurs throughout the State, the problem is somewhat greater in western New York.

In all areas where apple trees are grown, mineral fertilization is most effective only when there is adequate soil aeration (oxygen) and moisture. These conditions are necessary for root development.

knolls or also on heavier soils where the root system is restricted.

If potassium deficiency symptoms appear on the leaves, potash applications may be desirable while leaf symptoms are still apparent. Here the trees are fertilized individually according to their symptoms.

McIntosh apple trees maintained at borderline nitrogen levels will usually show tree to tree variation in the orchard. Here, again, the trees should be fertilized individually, depending on their appearance at harvest time.

Leaf and Soil Analysis

In New York we have a leaf-soil analysis service that aids growers on

. . . DIFFERING BY REGION, OFTEN BY ORCHARD, SOMETIMES EVEN BY INDIVIDUAL TREE.

By Elwood G. Fisher **Cornell University**

The Orchard

While nutrient deficiency problems differ according to area, each orchard presents its own particular fertilizer problems.

One orchard on very well drained soil may have severe magnesium deficiency, while a neighbor on heavier soil may have no such problem. Even areas within an orchard can present different fertilizer problems, often (not always), associated with soil contour. Boron deficiency may be a problem on high sandy knolls but not on lower areas with finer particle size. Potassium deficiency may occur on sandy

their lime, nitrogen, potassium, and magnesium problems. We also analyze for calcium and phosphorus, occasionally making tentative suggestions for phosphorus fertilization. We do not currently analyze for minor elements, so the grower must still fertilize with boron according to symptom expression.

Soil pH

We suggest the maintenance of a regular liming program that aims for a surface soil pH of 6.0. Actually little, if any, difference in apple tree performance can be determined between pH 5.3 to 6.6. But at a soil pH below 5.0, we often find magnesium

deficiency to be a problem. At a soil pH close to 7.0, certain minor elements are more likely to be deficient. Thus, we suggest growers aim at an in-between level of 6.0. Occasionally we find an acid surface soil combined with a subsoil that increases rapidly in pH. Here we are less inclined to suggest limestone application.

Soil magnesium is usually low where the soil is acid. Here we suggest a high magnesium dolomitic limestone. Occasionally the soil can be acid but soil analysis does not show low magnesium. Here we do not stress the need for limestone of high magnesium content.

Since soil acidity is greatest underneath tree branches, half or more of the limestone should be applied there.

Nitrogen

Fertilizer suggestions are based on leaf analysis for nitrogen. Most McIntosh apple trees in New York are maintained at nitrogen levels low enough to obtain maximum fruit quality and color consistent with annual yields. Our studies suggest that a leaf nitrogen level of 1.7 or 1.8% in August collected samples best meets these requirements.

The amount of nitrogen fertilizer required to maintain this level of leaf nitrogen may be about a pound of actual nitrogen per tree. There are a few orchards in New York where nitrogen has not been applied for ten years, yet the leaf nitrogen analysis remains at about 1.7 or 1.8% and annual production is maintained. Each orchard, then, must be fertilized, based upon grower experience. Even each tree must occasionally be fertilized individually. Tree variability often becomes apparent when borderline nitrogen levels are maintained and special fertilization depending on the appearance of the tree during late summer may be needed.

The rate of nitrogen fertilization should usually be slightly higher on varieties other than McIntosh and the leaf nitrogen level slightly higher, if annual bearing is to be maintained. The leaf nitrogen analysis of young trees, even of the McIntosh variety and also of older trees of processing varieties, should be close to 2.0%.

Because of individual tree variation and changes in leaf nitrogen caused by rainfall, crop, and sampling time, leaf analysis for nitrogen can be considered an aid, but no substitute for grower experience.

Potassium

A number of bearing apple orchards with less than 1.0% leaf potassium have appeared in our leaf analysis service. To the best of our knowledge, only two have failed to respond to potash fertilization. One was a heavy wet soil with obviously restricted root system; the other, an area where large amounts of soil had been placed under the trees and no tree roots could be found in the top foot of soil.

When leaf potassium was increased from below to above 1.0%, fruit size, color, yield, and vigor increased, while leaf scorch disappeared. Older orchards did not always show leaf scorch even at extremely low leaf potassium levels.

When leaf analysis was slightly above 1.0%, fruit size, color and yield responses were not too evident. For example, while potash fertilization resulted in more fruit color in one orchard, it caused little or no color in several other orchards. Currently fruit color response is not predictable.

On the other hand, fruit acidity did increase as leaf potassium increased, even up to high K levels. This was measured both by titration and taste panel results. Some acidity increases fruit quality, but excessive acidity from too high leaf potassium levels in a magnesium deficient orchard can lose the taste panel preference.

So, we set the leaf potassium level for diagnosing fertilizer needs of apple trees at about 1.3%—a level sufficiently above the potash hunger borderline

and below the possibility of increased problems from magnesium deficiency and undersirably high fruit acidity. As with nitrogen, this level might shift slightly with rainfall, crop, time of sampling, etc.

Although, we place greatest emphasis on leaf analysis, soil analysis (from surface and subsoil samples), often gives us valuable information not available from leaf analysis alone. Growers are sometimes disturbed that the analysis may show what normally would be a satisfactory soil level for potassium, yet low leaf potassium, or vice versa.

Soil and leaf analyses fail to jibe in slightly over ⅓ of the orchards sampled. In most instances, we can determine why the analyses do not jibe. For example:

1 Low leaf potassium may be due to low soil potassium, or it may be low because of high soil pH, calcium, and magnesium, poor soil drainage or high leaf nitrogen.

2 Low leaf potassium from poor soil drainage may require tiling and mulching to supplement soil application.

3 Low leaf potassium from high nitrogen may require reduced nitrogen fertilization or heavier-than-normal potash fertilization if high nitrogen is desired.

Where potassium is the main deficiency problem, we suggest no more than 10 pounds muriate of potash per mature tree over a 3-year period. Where low leaf and soil magnesium combine with low potassium, both potash and magnesium should be applied as an insurance measure, either as a mixed salt or in separate applications.

If leaf and soil potassium are low but not critical, and leaf and soil phosphorus also appear at low or borderline levels, a mixed fertilizer is suggested. Again, if potassium is low, but not critically so, with phosphorus satisfactory, we have suggested an N-K fertilizer of approximately 1-0-1 ratio.

At this time and place, the American Potash Institute pauses to pay its respects to the memory of one of the authors of this special issue, Dr. E. G. Fisher, for several years Extension Pomologist for New York State. Dr. Fisher died on April 25. He was a widely respected authority in mineral nutrition. With Dr. Damon Boynton, he developed the Leaf Analysis Service for New York fruit growers. He also served as pomologist for USDA, working on Tung tree culture in Florida. Additional interests included the use of radioactive isotopes and enzyme relationships in nutrition. Agricultural science will miss him.

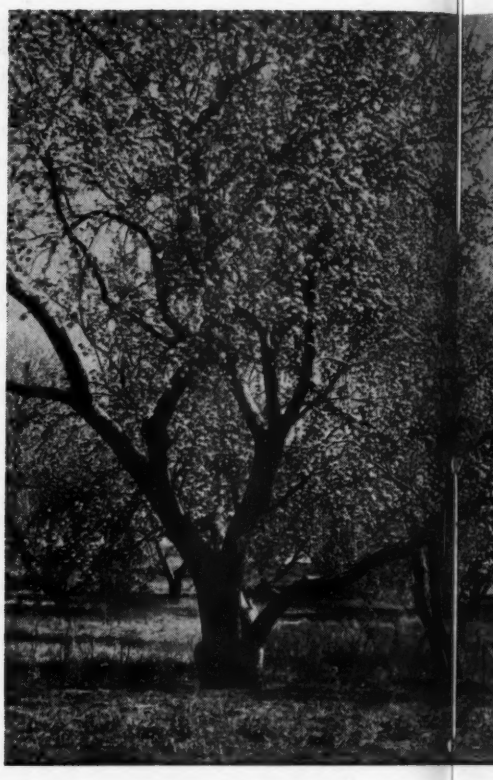
Magnesium

The normal seasonal curve for magnesium shows little change in leaf analysis from mid to late season.

In an orchard suffering magnesium deficiency, leaf magnesium may continue to drop during the latter part of the season. This means that leaf samples can be collected in *mid-summer* from two orchards showing similar analyses for magnesium, with one showing late season magnesium deficiency and the other no symptoms. This complicates the establishment of a critical or satisfactory level of leaf magnesium. From studies with the McIntosh variety and observation of other major varieties, we feel that leaf magnesium in August-collected samples should be .25 or .26% or higher.

By associating leaf analysis with appearance of deficiency symptoms, a critical level of .24% was established. Below this level magnesium deficiency

Continued on page 26



FROM NURSERY . . .

THEY REQUIRE SOUND MA

THROUGH leaf analysis surveys and other experimental evidence, Massachusetts horticulturists concluded "it is no longer possible to recommend a 'nitrogen alone' program for fertilizing Massachusetts apple orchards." The following table suggests the nitrogen and potassium needed for trees of different ages:

They also recommended for these fertilizers to be put on by band application under the spread of branches. When materials are broadcast over the whole orchard floor, it may be necessary to increase the rate of application in order to get the same tree response as the band application.

Magnesium requirements for orchard soils can best be met, they reported, by applying

Potential bushel yield of tree	Approxima	
	Nitrogen required	Potassi[u]m require
	Pounds N	Pounds
Less than 15	0.66	1.3
15–25	0.66–1.00	1.3–2.[6]
More than 25	1.33–2.00	2.7–4.[0]

D MANAGEMENT

. . . TO FRUIT

sufficient dolomitic lime to maintain a soil pH of 6.0 to 6.5. On orchards inadequately limed in the past, it may also be necessary to apply magnesium sulfate sprays to prevent occurrence of magnesium deficiency.

And boron, they said, should be applied to orchard soils every three to five years—with borax being the most common material. Recommended rates of application per tree vary with age and size from approximately ¼ lb. of borax on young trees, ½ to ¾ lb. on medium age and size trees, and ¾ to 1 lb. on large or mature trees. In no case, they suggested, should the rate of one application of borax exceed 50 lbs. per acre.

prximate amounts per tree

P assium quired	5–10–10	8–16–16
Po nds K_2O	Pounds	Pounds
1.3	13	8
3–2.0	13–20	8–12
7–4.3	26–40	16–25

Continued from page 23

leaf symptoms might occur. In one experiment, yield and fruit size was increased by increasing leaf magnesium from below to above .20%. Preharvest fruit drop increases as leaf magnesium drops from slightly above to below .20%. A .25 or .26% leaf magnesium level or more in August-collected samples is above the borderline, giving some safety if the orchard is one that will continue to drop in leaf magnesium.

Low leaf magnesium may be due to low soil pH and magnesium or high soil potassium. When due to high soil potassium, foliage sprays of epsom salts may supplement soil fertilization.

Leaf magnesium level can be affected by crop size and rainfall. We assume, however, that it should not be below about .24% even under conditions of heavy crop and high rainfall.

Measures for controlling magnesium deficiency include: (1) a regular liming program with high MgO dolomitic limestone to maintain a surface soil pH of 6.0, (2) supplemental soil or spray applications of magnesium sulphate, (3) maintenance of satisfactory leaf nitrogen level, and proper potassium balance.

Boron

In our leaf analysis service, we make no analysis for boron and can only suggest that if boron deficiency has ever shown on the fruit, boron should be included as part of the fertilizer program. Foliage spray applications of highly soluble sodium pentaborate compounds have recently been favored over soil application.

Rapid spectrographic methods of analysis for minor elements are now possible. Such equipment could include boron in a routine leaf analysis service. Tentative studies suggest that fruit analysis is more reliable than leaf analysis in determining boron requirements of apple trees.

Phosphorus

Although our leaf and soil analysis service has found a number of orchards with extremely low phosphate levels, heavy rates of phosphate fertilization demonstrated in such orchards have shown negative results so far.

Well replicated trials with other fruits on similar soils have shown small phosphorus responses, particularly at high nitrogen levels. If any response to phosphorus fertilization in the plots has occurred, it has been a small one, at least over a three-year period.

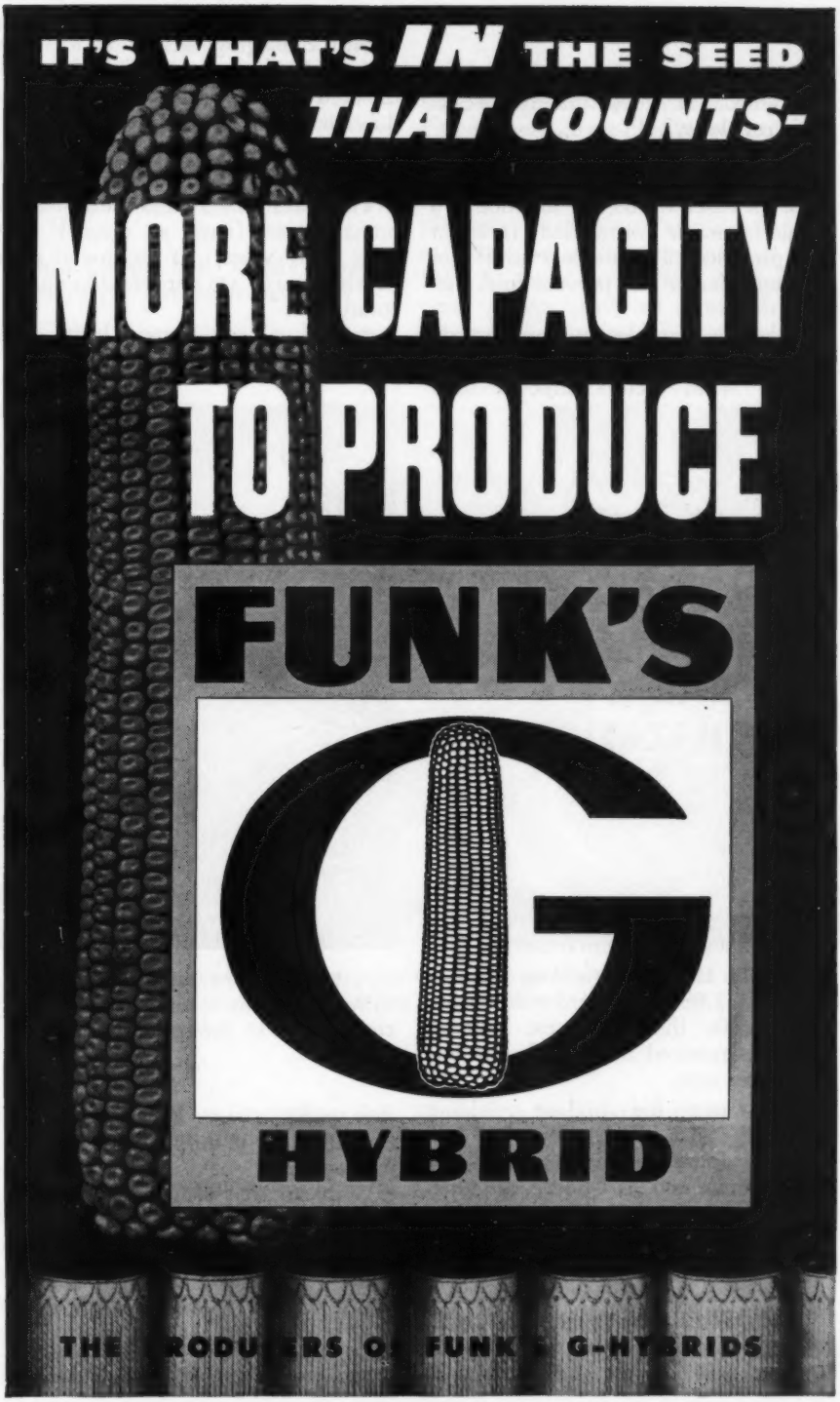
Nevertheless we do occasionally suggest the use of a mixed fertilizer as mentioned in the section on potassium.

Conclusion

The fertilizer requirements of one part of an orchard are not necessarily the same as another part of the same planting. In fact, apple trees may occasionally require individual fertilization. No one method of diagnosis, except perhaps the appearance of deficiency symptoms, is entirely foolproof. But by the time symptoms appear, considerable damage has already occurred and deficiencies such as magnesium require a number of years to correct.

In our New York diagnostic service, we combine both leaf and soil analyses. Observations by us and growers alike show a number of New York orchards profiting from fertilizer suggestions based on such analyses. When making these fertilizer suggestions, we always include the following statement: "We do not claim to be infallible in our diagnosis but know that we can do a much better job in making fertilizer suggestions for your orchards with, than without, the analytical results."

THE END


IT'S WHAT'S IN THE SEED
THAT COUNTS-
MORE CAPACITY
TO PRODUCE
FUNK'S
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THE RODU ERS O FUNK G-HY RIDS

WHY PECANS DEMAND LIBERAL FERTILIZATION

By L. M. Ware

WHAT does it take to produce high yields of good quality pecans with regularity?

Science—and experience—have shown that no one practice assures success. In other words, the absence of a single favorable (or needed) factor or the presence of a single critical (or limiting) factor can prevent final success.

Take, for example, the careful study made of 167 pecan orchards in Alabama. What factors affected their yield? These facts were found:

1 The 13 highest yielding orchards received 1,080 lbs. of fertilizer per acre, while the 21 lowest yielding orchards resulted from 54 lbs. of fertilizer per acre.

2 Among the highest yielding orchards, 100% had legumes, 98% had varieties fairly resistant to scab, 70% had summer sod, 70% had cattle grazing.

3 A high percentage had well-drained sites, deep friable soil, and absence of rosette.

Such factors may range from inadequate soil moisture and nutrients affecting tree growth and fruiting to the casebearer destroying specific nuts or scab damaging leaves.

Let's look at the interrelationships of some of these factors in pecan production.

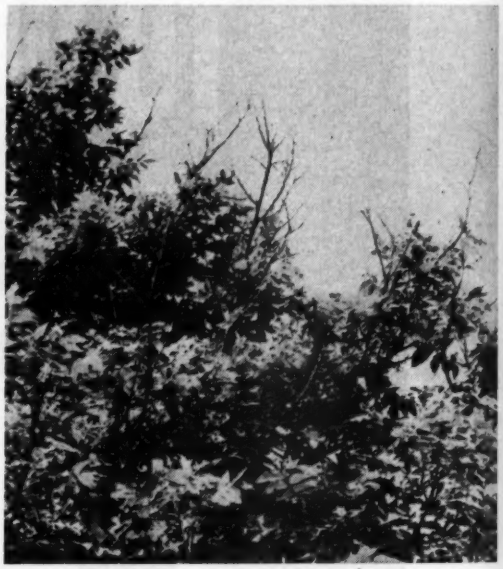
Pecan Different from Annual Crops

The basic differences between an orchard tree (such as pecan) that lives many years and an annual crop (such as corn) are important to understand.

An annual crop grows, fruits, and dies within a year, influenced by factors affecting it during the one growing season.

A pecan tree in a given year produces foliage, growth, catkins, and pistillate flowers . . . sets nuts . . . develops shells, hulls, kernels . . . and stores reserve foods in branches for future use.

Growing conditions of the past 1, 2, even 3 or more years largely determine



. . . to help prevent certain limiting factors (such as rosette) from causing crop failure or low production.

the pecan tree's growth, fruiting, and food storage in a given year. In fact, the nature of this expression (growth, fruiting, and food storage) in a given year will affect nut yield the next 1, 2, or even 3 years.

Some of the relationships indicated above are schematically shown on page 30.

What Causes Low Yield? Low Quality? Irregular Bearing?

Two sets of conditions usually cause low yield and quality as well as irregular bearing of the pecan:

1 Neglect, poor cultural and fertilizer practices, one or several limiting factors.

2 The problem of securing proper balance between growth and fruiting usually in well-managed orchards.

The first condition (or orchard) can usually be corrected by good fertilization, winter legumes, liming, zinc additions, and insect-disease control for nuts and foliage.

Auburn University

The second condition is more complicated. In productive orchards, an excessive set of nuts one year is usually followed by a light crop next year. A very heavy set of nuts drains hard on the tree's food reserves and minerals in developing hulls and shells, often leaving too little reserves to develop full kernels. Poor filling results.

On the other hand, a good but not excessive crop may result in good filling but exhaust the tree's stored food supply in developing the kernels. Often no nuts are produced the following year or even the following two years.

. . . to help insure healthy, abundant foliage retained well into the fall, providing conditions favorable to filling of nuts one year and the formation and set of nuts another year.

Prof. L. M. Ware has headed the Department of Horticulture at Auburn University since 1932. Named "Man of the Year" by *The Progressive Farmer* magazine last year, Prof. Ware is widely known for his work in sweet potato production, vegetable processing, vegetable irrigation, and pecan production.

The problem is one of balance—between growth and fruiting.

Photosynthesis and Soil Conditions

Although we have indicated no one factor in nut production should be considered more important than another, what a tree can and will do depends greatly on its manufacture and use of plant foods.

It works like this. Through adequate sunlight and healthy, abundant, long-lived leaves, the tree converts (or manufactures) plant food into a form the pecan can use. But before the tree can manufacture such food in sufficient quantities, it must have available adequate moisture and nutrients in the soil.

Thus, the behavior of the pecan is determined by the complex interplay of leaves, sunlight, and manufactured plant food on the one hand and soil moisture, nitrogen, and minerals on the other.

Good Production Conditions

Conditions most favorable for balanced growth, nut formation and development, and regular bearing are:

1 Sufficient food stored in twigs and branches during winter to give a good growth flush and insure initiation and set of pistillate flowers in spring.

2 Enough soil moisture and nitrogen to assure good shoot growth and abundant leaf area.

3 Leaves that remain active and healthy throughout the summer and fall.

4 A proper balance between plant foods, especially carbohydrates and nitrogen, to insure full but not excessive fruit buds and the set, development, and filling of nuts.

5 At year's end an adequate supply of tree-manufactured plant food for storage for the next year's crop.

RELATIONSHIPS BETWEEN FACTORS AND RESPONSES

External Factors	The Tree	Tree Response	Response Categories		
			Current Years		Future Years
Site	Foliage	Growth	Crop	Status	Expected
Soil	Amount	Leaf	size	of	crops
Water	Condition	Twig		reserve	next
Nutrients	Functioning	Fruiting		foods	1 to 3
Orchard practices	period	Fruit bud formation		after	years
Fertilizer	Photosynthesis	Catkin development		crop	
Culture	Amount	Pistillate flower			
Climatic factors	Use of product	development			
Rain	Regulators	Fruit set			
Sunshine	Auxins & others	Development	Heavy	Low	Light
Humidity	Reserve foods	Shell	Light	High	Heavy
Other factors	Carbohydrates	Hull	Medium	Medium	Medium
Insect attacks	Proteins	Kernel			
Disease attacks	Fats	Storage of food			
	Nutrients	reserves			
	Elements				

Anything that destroys the leaves, reduces their efficiency, or shortens the period of effective activity reduces the availability of manufactured plant food for the various activities of the tree.

Fertilizer Practices

The study in Alabama orchards showed a large percentage of high yielding orchards had (1) *winter legumes,* (2) *summer sod,* (3) *grazing,* and (4) *a liberal fertilizer application.*

Since winter legumes are usually planted in successful orchards, liming will usually be required. The soil should be tested and lime added if needed for cover crops. Since liming reduces zinc availability, a zinc application for rosette is recommended where the soil is limed.

When using winter legumes, phosphorus and potash should be applied in the fall. This should be followed in February with 500 to 600 pounds per acre of an 8-8-8 fertilizer in mature orchards.

Where no winter legume is grown, 1,200 to 1,500 pounds per acre of an 8-8-8 fertilizer should be added, one half in late February and one half in April. For young trees, 2 to 3 pounds of an 8-8-8 fertilizer per tree for each year of its age should be used.

Enterprising growers may adapt fertilizer and cultural practices to their own needs by handling orchards in a way that obtains a range of shoot growth for the different varieties: 2 to 6 inches for the *Success,* 3 to 8 inches for the *Moore* and *Moneymaker,* 3 to 10 inches for the *Schley, Elliott, Curtis,* and *Stuart.*

One half to 1 pound of zinc sulphate (36% Zn) per tree for each year of its age up to 10 pounds per tree applied to soil with the complete fertilizer in late February will usually correct rosette. In orchards with little or no visible rosette, 2 to 3 pounds per tree of zinc sulphate applied yearly with fertilizer is recommended for trees 20 years old or older. On alkaline soils spraying would be preferred.

Continued from page 14

ysis is of little value, particularly for such mobile elements as nitrogen and potassium. In finer textured soils, where natural soil fertility is higher and relatively stable over a period of time, soil analysis will find a useful place.

In Florida, recommendations for soil analysis are restricted to tests for soil pH (5.5 to 6.5 is thought optimum) and for excess copper (amounts over 150 lb. total Cu per acre). Liming on the basis of pH value is usually adequate, but liming for calcium nutrition alone is tentatively recommended where less than 300 lb. Ca per acre six inches is found.

Fruit Analysis

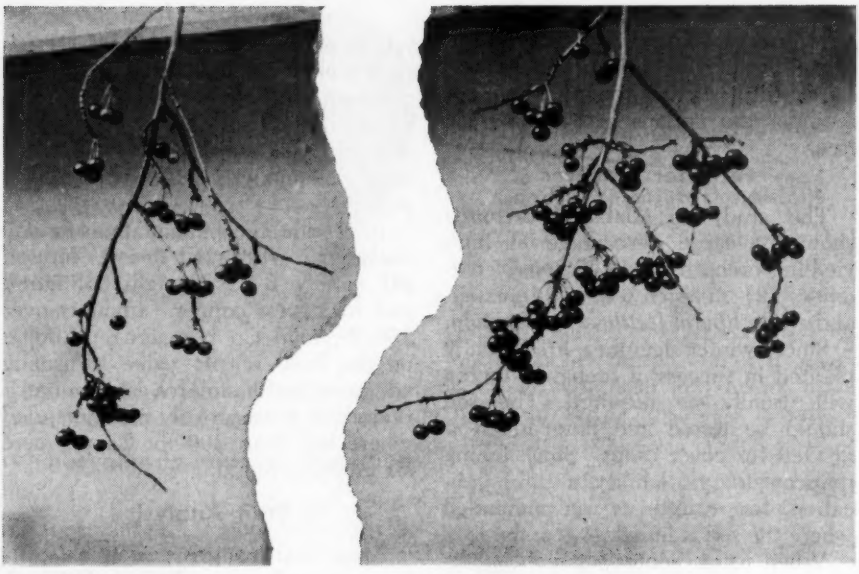
Many leaf analysis principles apply to mature fruit analysis. Although this area has not been explored adequately, it is known that fruit composition is relatively stable over a period of several weeks to a few months during its relatively mature period.

Further, most of the fruits on a citrus tree are approximately the same age, while the leaves on a citrus tree may be the result of several flushes, possibly covering a period of two years. This would make fruit sampling a less difficult problem than leaf sampling. Although the ranges of analytical values in fruit analysis are unfortunately somewhat less than the ranges in leaf analysis, this smaller range is compensated often by the relative stability of the fruit composition over the sampling period.

Summary

An optimal nutritional program will depend on careful evaluation of (1) the appearance of the trees, (2) the native fertility of the soil, (3) the fate of elements applied in fertilizers, (4) the fertilizer history, (5) leaf, soil, and fruit analyses, and (6) the decision of the grower to produce for the fresh fruit or for the processing market.

THE END



NO POTASH **WITH POTASH**

Figure 1—The left branch portion is from potash-deficient cherry tree that received supplemental nitrogen only. The right branch portion from tree that received 10 lbs. 0-0-60 in fall and 4 lbs. ammonium nitrate in spring prior to this crop. The year before the picture was taken the tree from which the *right* branch was taken showed extreme "curl leaf."

GET TOP CHERRY PRODUCTION

OPTIMUM cherry production comes from many related practices, including proper fertilization. The successful grower knows from experience that top tree growth and fruit yield come only from many factors working in harmony with adequate nutrition.

Annual Terminal Growth

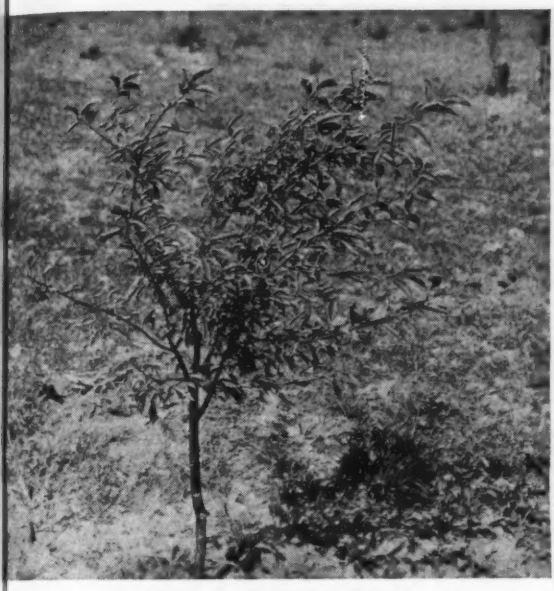
The length of its annual terminal growth is a good way to determine the growth rate a red tart cherry is making.

The tart cherry produces either *fruit buds* or *leaf buds* on one year wood, the kind depending largely on the tree's vigor as expressed in its terminal growth.

Short terminals (6″-10″) produce the majority of their buds as *flower buds,* with the ratio of *leaf buds to flower buds* increasing as twig diameter increases and the length reaches 12″ and beyond (Table I).

Fruit buds appearing on one year wood can produce fruit the following year, but no more. After that, the only remaining evidence will be a fruit scar and a bare spot on the twig.

Leaf bud on a branch making optimum growth will develop a spur that will perpetuate itself for several years.



SEVERE K HUNGER **ADEQUATE K**

Figure 2—They are both two years old. But one is a runt and the other a vigorous young cherry tree off to a good start. In this case, potash was the difference. The left tree is suffering from severe potash hunger, the right thriving after an application of barnyard manure at planting time. Note length of terminals and the normal foliage.

By F. A. Gilbert
University of Wisconsin

Thus, a bearing tree making an average terminal growth of 12″-18″ will build up a "spur system" approaching the productive capacity of the tree (Fig. 5).

Fruit buds on the spurs are more winter hardy than the lateral fruit buds on one year wood. This was proved during the rather severe winter of 1958-59 at Sturgeon Bay, Wisconsin (Table II).

It is possible to go to the extreme of excessive vegetative growth (20″+), causing predominantly lateral shoot growth with relatively few spurs.

Cultural Management

Due to sharp opinion differences on orchard culture under Wisconsin conditions in 1950, an experimental block was planted at the Peninsular Branch Experiment Station in Door County to determine best conditions for top cherry production.

Four cultural management systems are included in this study (*cultivation/cover crop, sod-mulch, mowed sod,* and *unmowed sod*). In this report, the two extremes (*cultivation/cover crop, unmowed sod*) will show the primary differences where shallow soil (12″-18″) and seasonal rainfall limitations may cause moisture deficiency.

Results from this study are summarized in Table III. Where moisture usually was the limiting factor under sod culture (Boyoucos moisture meter recordings), average terminal growth

Figure 3—When potash supply is inadequate, terminal growth can deteriorate as shown here. Normal terminal is at left, with terminals on right showing various degrees of deficiency.

(and thus the tree's productive capability) was restrained by competition from the sod. Optimum fertility was maintained in all blocks.

Results in many Door County orchards have upheld these findings, causing most orchardists to practice some type of cultivation-cover crop management.

History of Fertility Studies

Much of the early work suggested nitrogen as the only supplemental fertilizer justified, since little response had been seen from other elements. A comprehensive bibliography for the work prior to 1954 is included in the book, *Fruit Nutrition,* edited by Norman F. Childers (chapter 5, "Cherry Nutrition", F. B. Wann).

Wisconsin studies have been primarily concerned with *potassium supply* since earlier literature and a knowledge of fruit tree nutrition indicated a need for supplemental nitrogen. Perhaps this was best summarized by J. R. Magness, "Only the strongest orchard soils maintained under cultivation, or under a mulch of organic matter, supply the necessary amount of nitrogen without supplemental fertilization. Practically all orchards in the United States require supplemental nitrogen for optimum growth."

Nutritional studies have recently been expanded in all of the cherry producing areas, with major emphasis now being placed on potassium along with nitrogen.

Potassium Studies (Wis)

Potassium deficiency symptoms on Red Tart Cherries were reported by L. R. Langord in 1935 and 1938, A. R. Albert in 1950 and F. A. Gilbert in 1955.

In its early stages, K deficiency shows as an upward curling of the older leaves. In the more advanced stages, the foliage becomes bronze on the under surface and finally the margins of the leaves become necrotic.

TABLE I BUD DIFFERENTIATION

Length of Growth	Percent Fruit Buds	Percent Leaf Buds
1″–8″	92–100	0–8
8″–12″	80–100	0–20
*12″–18″	15–60	40–85
*18″–	0–25	75–100

*It was noted that very slender long terminals had a considerable number of fruit buds.

Terminal growth is only slightly depressed in the early stages, although terminals are definitely more slender. But as potash deficiency increases, terminal growth becomes very limited (Fig. 3).

As "curl leaf" trees continued to increase, an orchard with all trees free of actual deficiency signs was hard to find by 1950. With so many orchards showing potash deficiency it was not difficult to obtain uniformly deficient blocks for experimental purposes.

So, to prove the importance of potash to growers still applying only supplemental nitrogen, two experimental blocks and several demonstration areas were maintained for several years.

In one of the experimental blocks, trees receiving barnyard manure at planting (1949) were making excellent growth in 1950 (Fig. 2), while adjacent trees planted at the same time without manure were exhibiting extreme "curl leaf" symptoms (Fig. 2).

A comparison of the leaf analyses from the trees with and without the manure, giving percentages of elements on a dry weight basis, showed the following:

Nutrient Element	Normal Trees in Manured Area	"Curl leaf" in Trees in Adjacent area
Potassium (K)	1.61%	.40%
Calcium (Ca)	.99	1.23
Magnesium (Mg)	.36	.54
Phosphorous (P)	.195	.18
Nitrogen (N)	2.48	2.30

The manured block was selected (1) to determine how long it would take trees maintained on an "N-only" program to exhibit "curl leaf" symptoms and (2) simultaneously to compare this treatment with N-K and N-P-K programs. Substantiating the findings of other workers, this experiment showed (Fig. 4):

1 That potash deficiency depresses annual terminal growth with a corresponding decrease in fruit yield.

2 That an accumulative effect appears to occur from continued use of phosphate combined with nitrogen and potash.

Data from another orchard, selected for demonstration purposes because of severe "curl leaf" on mature trees, are shown in Table IV. Although this Schuyler block was for demonstration only, the results showed the same trends as the experimental blocks.

1 That both nitrogen and potas-

TABLE II WINTER HARDINESS OF RED TART CHERRY FRUIT BUDS

Date Examined	Lateral Buds		Spur Buds	
	Total Number	% Alive	Total Number	% Alive
February 8, 1959	2305	59	1714	94
March 2, 1959	3318	37	4090	70

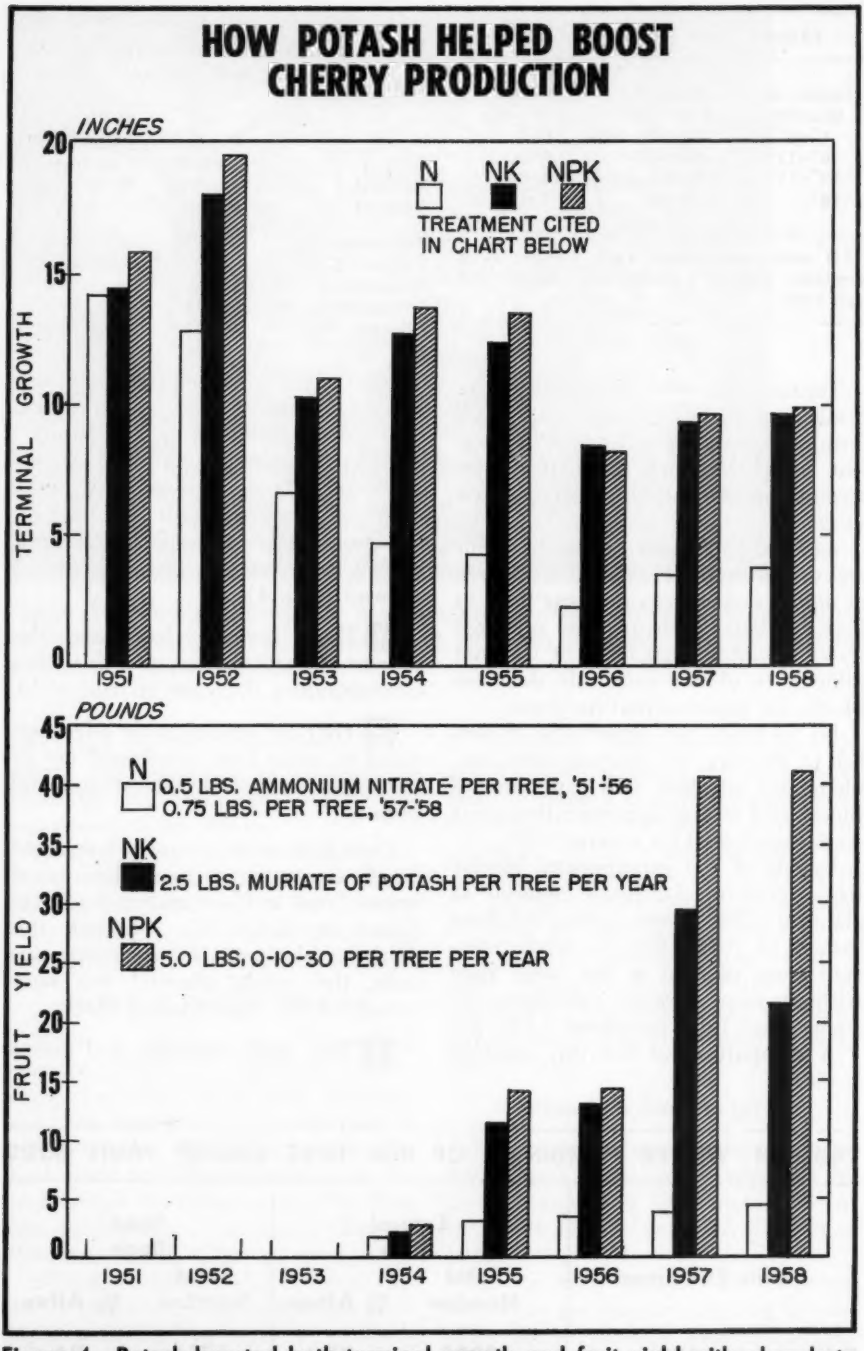


Figure 4—Potash boosted both terminal growth and fruit yield with phosphate producing definite yield response in 1957 and '58. (Trees planted in 1949, manured at planting, excellent growth in 1950.)

Figure 5—This is a branch from a 6 year old Montmorency tree with an excellent fruiting system that resulted from annual terminal growths ranging between 12" and 18". Leaves were removed from the 2 and 3 year wood to show the spurs and fruit.

sium are needed for satisfactory tree growth and yields (Fig. 1).

2 That eliminating potash after initial correction will quickly cause reduced yields under Door County conditions with a soil having a parent material of Niagra limestone (Treatments 2 and 3.

3 That continued use of N-P-K gave the best accumulative results (Treatment 5).

Although major emphasis has been with nitrogen and potash, some interesting but inconclusive results have come from supplementary potash in an N-K program. Because of this and some foliage evidence of boron, iron, and manganese deficiencies, Wisconsin studies are expanding to cover these problems.

Summary

1 Bearing cherry trees must make 12" to 18" annual terminal growth to approach productive capacity of the tree.

2 Both nitrogen and potash are necessary for optimum tree growth and fruit production.

3 Additional tests are needed to determine the place of phosphate and its accumulative effect on tree growth and fruit production.

4 Expanded studies are needed to determine all factors responsible for tree growth, fruit set, fruit yield, and annual productive capacity of the Red Tart Cherry.

Note: The author has tried to be "non-specific" in suggesting rates or cultural management systems that would apply throughout the cherry producing areas, since conditions vary so much by areas. But it was necessary to show how certain factors limit

TABLE III CULTURAL MANAGEMENT STUDIES

Peninsular Branch Experiment Station — Trees Planted in 1951

Treatments	1955	1956	1957 [2]	1958 [3]	1959
			Average Terminal Growth (Inches)		
Unmowed Sod	10.8	5.1	4.6	9.6	6.6
Cultivation [1]	17.4	11.0	11.6	16.0	11.0
			Fruit Yield (Pounds)		
Unmowed Sod	3.6	6.0	—	0.1	5.9
Cultivation	9.8	16.2	—	12.0	32.6
			Fruit Size (Wt. in grams of 200 Fruits)		
Unmowed Sod	687	645	—	880	715
Cultivation	847	765	—	1000	846
			Number of Spurs		
Unmowed Sod	307	408	—	—	—
Cultivation	626	1215	—	—	—
			Leaf Area (25 Terminal Leaves sq. in.)		
Unmowed Sod	79	—	68	—	—
Cultivation	104	—	108	—	—
			Number of Leaves per Spur		
Unmowed Sod	—	—	4.1	4.7	—
Cultivation	—	—	5.4	5.2	—

[1] **Cultivated plots have a cover crop of winter wheat.**
[2] **Yield records were not taken due to variability of yields as a result of leaf spot infection in 1956 and frost during bloom.**
[3] **Area crop light due to spring frost.**

the growth and productivity of a cherry tree and how some of these "limitations" might be partially corrected.

Fertilizer recommendations in Door County are based on soil samples and growth status of the trees, leaving no specific recommendation for all orchards.

In general, recommendations for bearing trees under a system of clean cultivation with a cover crop have been as follows:

Evidence of Potash deficiency (leaf symptoms)

5-10 lbs. muriate of potash per tree in fall of year symptoms are observed.

Maintenance program.

Nitrogen supplied annually at the rate of 1 lb. of ammonium

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TABLE IV CHERRY YIELD DATA—SCHUYLER ORCHARD*

Treatments per Tree	Amounts	Average Yield, lbs./tree					
		1951	1952	1953	1954	1955	Ave. per Year
1	33–0–0 4 lbs. ('51–'55)	52.0	30.4	48.1	40.5	42.7	42.7
2	33–0–0 4 lbs. ('51–'55) 0–0–60 5 lbs. ('50, '51, '53)	87.2	58.4	73.4	77.9	77.8	74.9
3	33–0–0 4 lbs. ('51–'55) 0–0–60 10 lbs. ('50, '51)	124.0	82.4	134.2	80.3	72.9	98.7
4	33–0–0 2 lbs. ('51–'55) 0–0–60 5 lbs. ('50, '51, '53)	75.2	20.8	59.5	53.7	39.3	59.7
5	33–0–0 2 lbs. ('51–'52) 4 lbs. ('54) 10–10–10 10 lbs. ('51–'55)	100.0	74.4	136.2	77.7	210.7	119.8

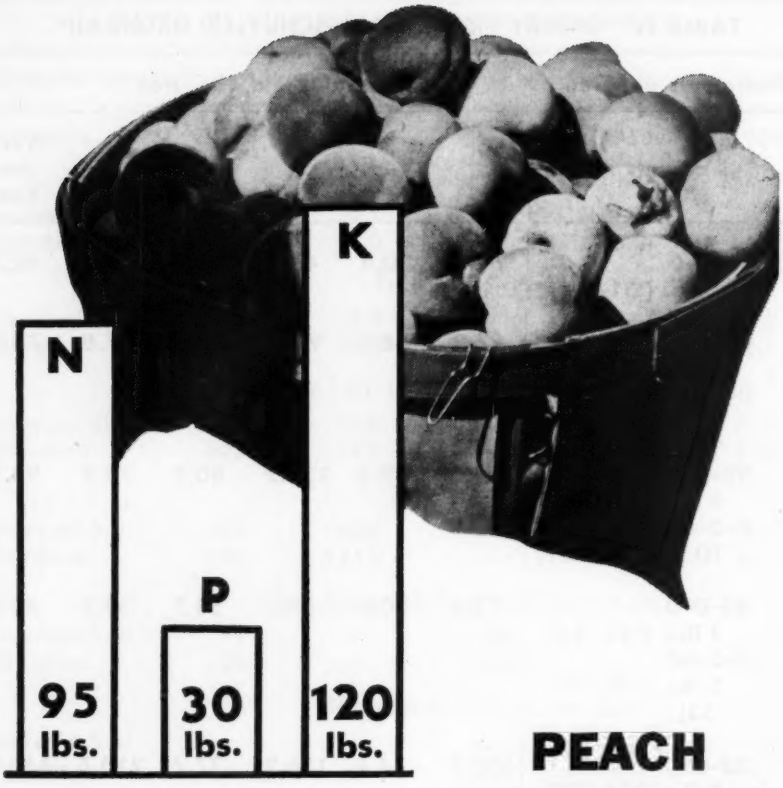
*** The trees in this orchard were 25 years old and were exhibiting extreme "curl leaf" symptoms.**

nitrate (or equivalent) for each 8 years of age of the tree. P-K supplied in approximately a 3-1-3 ratio either as complete fertilizer or as a separate application of 0-10-30 with the nitrogen supplied as a separate application.

THE END

Put on Colorful Meetings
With Color Slide Sets on Fertilizer Placement, Soybean Production, Alfalfa Management, and Potash Hunger Signs

Easy Ordering on Page 18



When 600 bushels of peaches remove this much plant food per acre, the importance of peach nutrition is clear.

PEACH NUTRITION

A RELATIVELY HIGH DEMAND

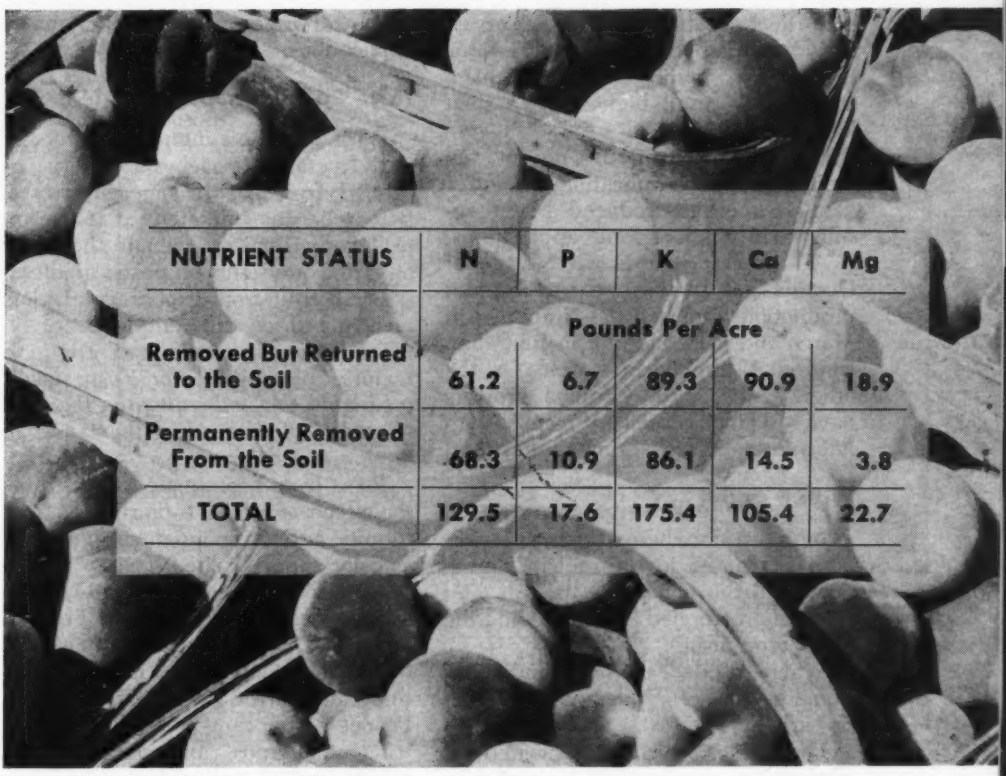
FEW OTHER fruits are grown as widely and under such varying soil and climatic conditions as the peach.

Introduced into Persia from China, peach cultivation has extended throughout much of the world, with extensive plantings in Europe, Asia, South Africa, Australia, South America, and the United States. Today, peach varieties grow in virtually every state of the Union.

To meet local region and climatic conditions, as well as consumer demands, many peach varieties have been developed. These different varieties may explain some of the differences in response to added nutrients.

Since peach bears its fruit on last year's wood, moderately vigorous shoot growth with thick girth and plump fruit buds should be induced for maximum high quality fruit. This requires careful cultivation, pruning, and fertilization.

Nutritionists agree that the peach has a relatively high demand for nitrogen and potash, responding to one or both of these nutrients under most conditions. On light textured soils, low in organic matter, the peach may also respond to phosphorus, calcium, magnesium, zinc, iron, and boron additions.



NUTRIENT STATUS	N	P	K	Ca	Mg
	Pounds Per Acre				
Removed But Returned to the Soil	61.2	6.7	89.3	90.9	18.9
Permanently Removed From the Soil	68.3	10.9	86.1	14.5	3.8
TOTAL	129.5	17.6	175.4	105.4	22.7

Figure 1—An acre of mature peach trees removes many pounds of necessary nutrients from the soil.

By Roy J. Ferree
Clemson College

B. L. Rogers, et al. estimated early utilization of essential elements by mature peach trees. Figure 1 shows the different elements consumed by an acre of mature peach trees producing 275 pounds of fruit per tree with 108 trees per acre. These values expressed on an acre basis would not vary greatly with the number of trees per acre provided yield was approximately the same.

Plant nutrient removal is very closely related to yield. In general, the higher the yield, the greater the nutrient removal. Published data indicates that a yield of 600 bushels of peaches per acre removes 95 pounds of N, 30 pounds of P_2O_5, and 120 pounds of K_2O.

Nitrogen Needed Annually

In most peach growing sections, good tree growth and high peach yields demand annual applications of nitrogen-containing fertilizers. Increased yields come from increased size of individual fruits or better fruit set. Since nitrogen apparently is not translocated laterally in peach trees, it should be banded or distributed on the soil surface for good growth and production.

When to Apply

Time of applying nitrogen fertilizer

may affect peach yields. In some areas, early spring applications about two or three weeks before blossoming have frequently caused higher yields than later applications.

On lighter textured soils in the Southeast, split applications of nitrogen have often produced better results than single spring applications. F. F. Cowart and E. G. Savage of Georgia got better tree growth and production from half the N applied in March and the other half in June than from all N applied in March. On the other hand, South Carolina growers have obtained excellent results with late winter or early spring applications.

With P and K

In general, where a winter cover crop is planted in the orchard, practically all the phosphate, potash, and calcium are applied before seeding the cover crop in fall.

Where needed, nitrogen and additional potash are applied in late winter or early spring.

Post-harvest nitrogen is sometimes applied on early maturing varieties to promote fruit bud set. It may also be wise to apply judicious amounts of post-harvest N after heavy cropping and during years of unfavorable weather.

Effect on Color

Red color of peach fruits usually declines with increasing nitrogen. This has been attributed to the shade of increased leaf area stimulated by nitrogen. Delayed ripening frequently accompanies nitrogen fertilization also, especially where relatively large amounts have been used.

Leon Havis found that time of nitrogen application influenced peach color greatly. Although fall fertilization coupled with late discing caused deepest red skin color of Elberta peaches, yields were lower than when the fertilizer was applied in the spring or when it was divided equally between fall, spring, and early summer applications.

Taste Panels Choose High N-K

With increased interest in processing freestone peaches, quality of canned fruit has become important. Research was initiated at Clemson College in 1959 to evaluate the effect of various nutrients on peach quality.

Fresh fruit from experimental plots receiving three different levels of N, P, and K were graded according to texture, color, and flavor. *Taste panels invariably selected fruit from the high N and K plots, grading them best in texture and color.*

Plans have been made to determine the effects of nutrients on ripening uniformity and shipping quality, as well as color and shelf-life.

In studying the effect of nitrogen on canned peach quality, E. L. Proebsting, et al., found high N applications resulting in acceptable firmness, texture, and flavor of Elberta peaches. Peaches from low-N trees were astringent, fibrous, and soft. Tannin, soluble solids, and acidity were lower while ascorbic acid was higher in fruits from trees receiving 2 pounds actual N per tree.

Phosphate Best Combined

Phosphate is important for good yields and quality, although tests of foliage and other tree parts have indicated little phosphate used by peaches. Best results in peach orchards have usually occurred when P_2O_5 was combined with nitrogen and potash. Although phosphate alone has seldom proved practical, one notable exception was observed in North Carolina's Sand Hills. Peach trees responded to phosphate on freshly cleared land containing less than 5 pounds of soluble phosphate per acre. Here phosphate fertilization resulted in (1) increased tree growth, (2) better fruit quality, and (3) more marketable fruit.

Potash Hunger Frequent

Potash deficiency in peach orchards shows up frequently on both light and heavy-textured soils. Bearing trees suffering potash hunger have often exhibited no clear-cut symptoms until about two weeks prior to fruit harvest. Young trees have displayed symptoms two to four years after planting. Peach trees needing potash have responded within a few weeks to adequate applications.

Leaf analysis is a reliable way to determine the K status of peach trees. Reliable results have come from testing mid-shoot leaves collected during July or August. When potash percentage on dry weight basis has fallen below 1%, peach trees have responded to potash fertilizers.

Meeting Micronutrient Needs

Although facts about micronutrient effects on peach growth are limited, zinc deficiency seems widespread on certain soils of the Southeast and the far West.

In a minor element test on young trees in a Sand Hills orchard of South Carolina in 1946, we included magnesium, manganese, boron, zinc, and copper. Trees receiving NPK plus all five minor elements showed excellent growth, responding to all nutrients but copper.

Zinc Experience

Light textured soils, especially the Lakeland and Norfolk sands and sandy loams, need both zinc and magnesium, South Carolina tests show. Zinc deficiency on Lynchburg, Coxville, and Ruston soils has also shown up.

Seedling trees showing zinc hunger often will not show deficiency when they reach bearing age, probably because zinc was included in sprays for bacterial leaf spot. Even so, one or two year old trees should receive one or two zinc sprayings during each of the first two summers, perhaps along with a summer spray for borer control.

Horticulturist Roy J. Ferree is Leader of Horticulture Extension Work for Clemson College Extension Service. Native of the largest peach producing county in the East, he earned his M.S. in Horticulture from Clemson, his M.S. in Pomology from Rutgers.

Zinc sulphate sprays, applied during dormancy have been successfully used in California and elsewhere.

Magnesium Experience

Peach leaves showing a marginal chlorosis or an interveinal necrotic spotting on 5 to 7 year old peach trees in North Carolina were described by A. C. McClung as magnesium deficiency. Both abnormalities were greatly reduced by applying about 1 pound MgO per tree.

Mid-shoot leaves from trees not receiving magnesium fertilization ranged from 0.13 to 0.19% Mg. Leaves from magnesium-fertilized trees contained 0.31 to 0.39% Mg. Analysis of soil samples from under the spread of branches indicated exchangeable magnesium content of Lakeland surface soil was 0.05 me. per 100 grams.

Boron Experience

Boron deficiency on peach trees has been reported, with responses showing up in the Sand Hill region of the two Carolinas and Canada. Boron hunger can be detected by reduced leaf size, short internodes, excessive branching, reduced fruit set and yield.

Plant Testing Variables

In leaf analysis, many variables may affect leaf concentrations, including physiological maturity, crop load, variety, sample size, position, pruning, and fertilization.

Such as Moisture

Surveying nutrient status of Missouri orchards, A. D. Hibbard and Mohsen Nour found P and K leaf values varying with moisture supply. Through irrigation they could secure paired samples from blocks similar in most respects except for degree of moisture deficiency during extended drought.

They also found that potash concentration in the leaves decreased with increasing moisture stress, regardless of the soil's K content. Since plants growing under moisture stress cannot absorb both potash and phosphate readily, an abundant supply must be available to maintain high plant levels. Also crops with adequate moisture will deplete the soil supply of elements sooner, requiring more frequent applications to maintain adequate plant levels.

Such as Fluctuations

Little attention has been given daily fluctuations in leaf composition and their possible influence on the accuracy of leaf analytical results. But it seems reasonable to expect that vast changes in light, temperature, and moisture stress to which the plant is exposed throughout the day can influence the nutritive composition of the leaf.

Percentages of nitrogen, phosphorus, zinc, copper, and potassium in peach leaves ran highest in early June, declining as the season progressed with a tendency to level off in late July and August, A. C. McClung and W. L. Lott have found. Percentages of calcium, magnesium, manganese, iron, and boron increased throughout the season tending to remain relatively constant during the latter part of the sampling season, which extended through mid-September.

Such as Crop Load

When using leaf testing results to diagnose nutrient needs of peach trees, J. Popenoe and L. E. Scott urge us to remember crop load and fertilization. While crop removal reduced percentages of nitrogen, calcium, and magnesium in the leaves, phosphate and potash showed increases. The effects of both crop load and potash application were apparent by the middle of the growing season.

Values of Irrigation

Although peach crops have been irrigated for a long time in arid regions, it is a rather new practice in the humid East and Southeast, stimulated largely by periodic droughts. Water storage is most important, pomologists agree, during *pit hardening* and *final swelling* in fruit development. But water deficiency at any time of the growing season may reduce fruit size and yield.

Testing 8 year old peach trees of the Golden Jubilee, New Day, and Elberta varieties, Joshua Feldstein and N. F. Childers saw irrigation do this:

1 Increase Golden Jubilee yield 160 bushels per acre.

2 Cause 95% of the fruit to average 2¼ inches and larger, in contrast with only 40% such fruit from non-irrigated trees.

3 Cause fruit to ripen uniformly and to be harvested in one picking, in contrast with two pickings required by non-irrigated trees.

4 Cause fruit to ripen 2 to 3 days earlier than non-irrigated fruit.

Balanced Fertility Pays Off

Before 1934, most peach growers used only nitrogen to increase their tree vigor and yield, largely because most reported responses were from nitrogen. As yield and size declined, the need for other nutrients became apparent.

Using nitrogen, NPK with dolomitic limestone, and NPK with basic slag as variables in peach demonstrations, E. H. Rawl of South Carolina found the

NPK trees producing more than twice as much as the N-alone trees.

As early as 1929, some L. E. Scott experiments showed remarkable peach tree response to potash and phosphate fertilization in the Sand Hill area of the Southeast. These facts stood out:

1 Although maximum yields came from NPK fertilization, trees receiving only N and K followed closely.

2 While trees receiving only N and P yielded much better than N-only trees, the N-only trees produced no better than the unfertilized trees.

3 Potash hunger showed up on the no-potash trees only after the second crop had been produced.

4 This potash hunger appeared as slightly chlorotic leaves, tending to roll, first evident at the shoot tips, progressing inward toward the tree trunk.

5 Potash deficiency symptoms became more pronounced each year.

General Recommendations

Soils, climate, and fruit varieties vary too much to make general fertilizer recommendations for peaches throughout the United States. While recognizing soil and plant testing as top tools for detecting your nutrient needs, actual experience by successful growers should not go unheeded:

1 Such as the South Carolina peach growers who have gotten good results by applying 800 to 1,000 lbs. of 6-9-12 per acre to mature trees.

2 And the Alabama, Georgia, North Carolina, and Louisiana growers who have used approximately 600 lbs. of 8-8-8 per acre to increase yields and maintain vigorous trees—splitting the application to assure good cover crop growth when that practice is used.

THE END

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LaMotte Soil Testing Service is the direct result of 30 years of extensive cooperative research. As a result, all LaMotte methods are approved procedures, field tested and checked for accuracy in actual plant studies. These methods are flexible and are capable of application to all types of soil, with proper interpretation to compensate for any special local soil conditions.

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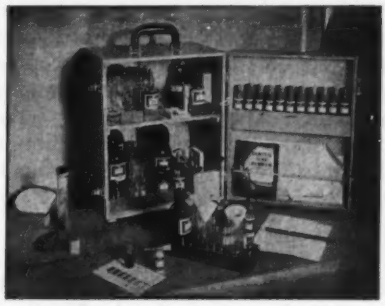
Ammonia Nitrogen	Iron
Nitrate Nitrogen	pH (acidity and alkalinity)
Nitrite Nitrogen	Manganese
Available Potash	Magnesium
Available Phosphorus	Aluminum
Chlorides	Replaceable Calcium
Sulfates	

Tests for Organic Matter and Nutrient Solutions (hydroculture) furnished only as separate units.



LaMotte Combination Soil Testing Outfit

Standard model for pH, Nitrate, Phosphorus and Potash. Complete with instructions.

Illustrated literature will be sent upon request without obligation.

LaMotte Chemical Products Co.

Dept. BC Chestertown, Md.

Continued from page 4

The relationship of fruit size and an adequate potassium supply has been noted in peaches, pears, and prunes. This establishes a new criterion which may perhaps be used in assaying the need or response of fruit trees to potassium fertilizers.

Correcting Potash Hunger in Western Orchards

Potassium correction in soils of semi-arid western orchards generally requires heavy massive applications of potassic fertilizers. This is due largely to (1) high fixation in the surface soil, (2) absence of tree root in this depth in summer, and (3) overabundance of magnesium and calcium.

On practically all but the most sandy soils, 25 pounds sulfate of potash per tree are necessary. Lower amounts (10 pounds potassium sulfate) have been found adequate on certain acid soils in the foothill areas. These massive applications are frequently effective for 5 or more years. Deep placement also increases the response. Reappearance of symptoms or a leaf analysis may indicate when to repeat the treatment. Small amounts of potassic fertilizers applied annually seem to be ineffective.

Magnesium

Magnesium deficiency is rarely found in western orchards. The high magnesium content of western orchard soils generally precludes such deficiency developing from present fertilizer practices.

Magnesium deficiency symptoms are clear: A marginal and interveinal chlorosis and leaf scorch with accompanying shedding of basal shoot leaves are easy to recognize. It occurs on acid soils. It can best be corrected by applying magnesium oxide to the soil or using foliage sprays containing a magnesium salt.

Leaf analysis showing less than 0.3 per cent magnesium in dry leaf matter in midsummer generally means deficiency. Magnesium deficiency symptoms are made more acute by fertilizers that leave an acid residue.

Minor Element Fertilization

Other elements—as important to growth as nitrogen, phosphorus, potassium, and magnesium—are required in much smaller quantities and often applied by foliage sprays. They include zinc, boron, iron, and manganese.

Zinc

Of greatest importance to western orchards is the minor element zinc. Prior to its discovery in 1930, a widespread condition in all species known only then as little-leaf is now recognized as zinc deficiency.

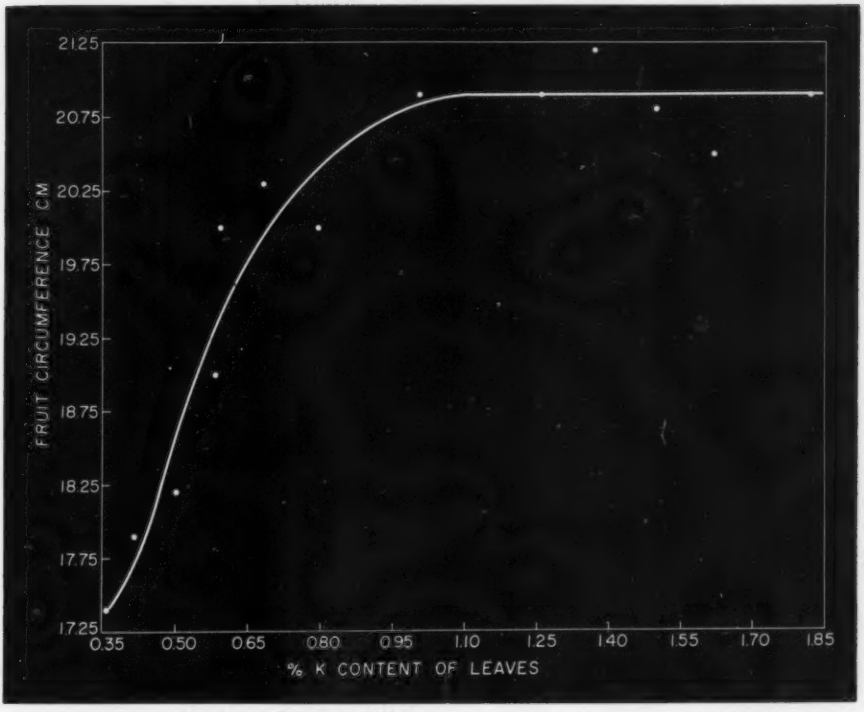
While the limits of deficiency are not too well defined, much data suggests a leaf analysis value of 12 ppm or less accompanies visible deficiency symptoms. Although correction varies with species, a dormant spray of 25 pounds zinc sulfate per 100 gallons of water has generally corrected mature trees in apple, peach, plum, prune, almond, and pear orchards. Cherry and walnut trees suffering zinc deficiency have not been readily corrected by zinc sulfate sprays. They have required several staggered rows of galvanized metal pieces driven into and around the trunks or large limbs of these trees.

The dormant spray of 25 pounds zinc sulfate generally corrects the symptoms for a few years but must be supplemented with later zinc often included with regular Bordeaux sprays applied in the spring.

Boron

Although boron has been most frequently associated with excesses in western orchards, more recent investigations have uncovered new deficiencies.

In prunes, brushy branch of prune trees—an excessive multiple branch-



This clearly shows how potash hunger is closely associated with small fruit. Note the relationship between potash content of spur leaves from Bartlett pear trees and fruit size at harvest. Leaf samples June 1—harvest August 1. Each value comes from the averages of 5 trees and 250 fruit measurements (50 fruits from each of 5 trees).

ing in the tree tops accompanied by marked reduction in fruit set—has recently been identified as boron deficiency.

In almonds, nuts failing to develop with early shedding and abortion of the nut embryos can occur.

In pears, blossom blast, twig die-back, and shallow depressions in the fruits are all boron deficiency signs.

In apples, external or internal cork occurs in the fruit, though apple trees in some districts of California may also exhibit severe die-back without any fruit symptoms.

In European shipping plums, such varieties as President and Giant sometimes exhibit brown sunken areas in the flesh which have been corrected by boron applications. Only the fruit showed injury. Injured shoots of prune and other species often remain partly alive well into the growing season, a characteristic that frequently distinguishes boron deficiency from other forms of die-back.

The symptoms described above occur when boron is at a threshold point between deficiency and injury, making it difficult to establish by leaf analysis a single value that will differentiate normal and deficient trees. Samples from affected trees, however, are generally lower than from unaffected orchards.

Whenever the symptoms above are associated with values less than 30 ppm boron, a deficiency should be anticipated. A late spray application before leaffall or an early spring spray

will generally reduce the symptoms and confirm the earlier diagnosis. Sprays or soil treatments can then be continued.

Plants in general and fruit trees in particular are very sensitive to boron excess. Soil applications of boron should not exceed 50 pounds per acre to avoid injury. A single soil treatment can be expected to be effective from three to five years.

Iron

Iron deficiency, generally referred to as iron chlorosis, is present in many western fruit districts. It is so frequently related to calcareous soils that it is also referred to as lime-induced chlorosis.

Although chemical analyses of carefully washed leaves have often shown a direct relationship between iron content and degree of chlorosis, sometimes this relationship does not seem to exist. For this reason, leaf analysis is not always dependable for diagnosing iron deficiency.

Correcting iron chlorosis in fruit trees is difficult. Dry salt injections of ferric citrate of ferric oxalate into holes in the trunk of pear trees have been helpful. More recently large applications of soil sulfur, 2500-5000 pounds per acre have corrected iron chlorosis in several peach orchards for 3-5 years. Iron chelates have also shown some correction and may become commercially important when costs permit usage. As much as 300 to 500 pounds per acre are needed to correct iron chlorosis in some trials.

Mild cases of iron deficiency can be improved by avoiding over-irrigation and using fertilizers that leave an acid residue.

Manganese

Manganese (Mn) deficiency in the orchard produces a rather distinct leaf pattern with many deciduous fruit trees. The midrib and main veins with adjacent bands of tissue of varying width remain green while the peripheral areas are chlorotic.

Very severe deficiency, causing necrotic areas, finally results in a shot hole appearance. Deficiency is generally associated with less than 20 ppm Mn in the leaf.

Manganese availability in western orchards depends largely on the pH of the soil. Alkalinity reduces the manganese while soil acidity increases its availability. Acidic fertilizers such as ammonium sulfate are therefore recommended when a manganese leaf pattern exists.

Manganese deficiency can be corrected by an early spring spray applied annually as soon as leaf area is adequate to absorb the spray. A one per cent manganese sulfate solution will correct and may be used as diagnostic step since improvement may often be attained in a two-week period. Some evidence indicates fruit trees can tolerate a mild manganese deficiency without appreciable decrease in yields.

Correction can also be obtained by placing 5-10 pounds manganese sulfate in a trench under the drip of the tree. Adding an equal quantity of sulfur together with the manganese salt increases the effectiveness and may serve for 5 years or longer.

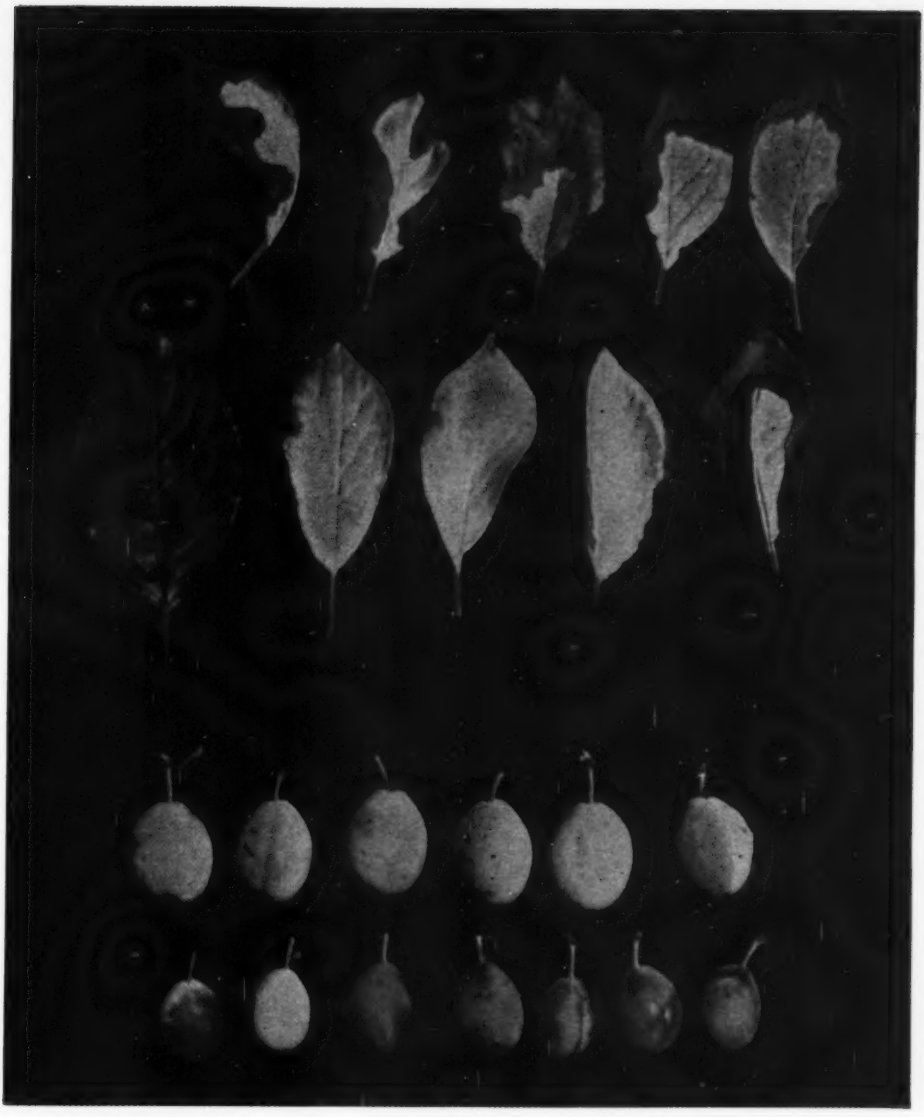
Other Factors Limiting Fertilizer Response

An unfavorable root environment frequently produces deficiency symptoms not easily corrected by adding fertilizers or soil amendments.

A high water table, an extremely dense soil, or the presence of nematodes may produce deficiencies difficult to remedy.

The effect of salinity or alkalinity may sometimes be confused with deficiency symptoms, but can frequently be clarified by a more complete leaf analysis.

THE END



WHY ORCHARD FERTILIZATION?

THE SHARP contrast in prune leaves and prune fruit (above) shows the role of potash in producing this fruit. A healthy French prune leaf (on left) will contain 1% or more K when sampled in July. The leaves showing various stages of K deficiency (on right) contained as little as .27% potash.

The fruit from K deficient trees (in lower row) are small, showing premature coloring and having poor quality. The fruit from trees adequately supplied with K (in top row) are larger and of much better quality. (From Gilroy, Calif. test)

Ranging from peaches to pecans, *Better Crops* magazine has tried to show the importance of orchard fertilization in the grower's perennial struggle with factors that would limit his yields and profits. As Dr. Kenworthy explained it, successful orchard fertilization depends basically on the *right kind* at the *right time* in the *right place* in the *right amounts.*

(Chairman of this special issue was J. Fielding Reed, Institute Southern Director)

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